SEVENTH ANNUAL REPORT

of the

U. S. Regional Pasture Research Laboratory

State College, Pa.

1943

1943

Seventh Annual Report

U. S. Regional Pasture Research Laboratory

State College, Pennsylvania

Division of Forage Crops and Diseases

Bureau of Plant Industry, Soils, and Agricultural Engineering

and

The Agricultural Experiment Stations

of the

Northeastern States

Cooperating

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Forty-five copies of this Report were made and distributed as follows:

Seven copies to the Division of Forage Crops and Diseases; one copy to each of the twelve Directors of the cooperating State Agricultural Experiment Stations in the Northeastern United States; one copy to the President of The Pennsylvania State College; one copy to the Conservator of the Northeastern Region of the Soil Conservation Service, Upper Darby, Pennsylvania; one copy to the Director of each of the following State Agricultural Experiment Stations--Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin; one copy to the Dominion Agrostologist, Ottawa, Canada; one copy to the Main Library of the Department of Agriculture, Ottawa, Canada; one copy to the Director of the Welsh Plant Breeding Station, Aberystwyth, Wales; one copy to the Director of the Swedish Seed Growers Association, Svalof, Sweden; one copy to the Director of the Waite Agricultural Research Institute, Adelaide, Australia; one copy to the Librarian, Division of Plant Industry, Council for Scientific and Industrial Research, Canberra City, A.C.T., Australia; and the remaining four copies to the U. S. Regional Pasture Research Laboratory.

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This annual report of activity at the Pasture Laboratory, as well as of that at the state stations with which the Laboratory cooperates, is a progress report and as such may contain statements which may or may not be verified by subsequent experiments. The fact that any statement has been made herein does not necessarily constitute publication. For this reason citation to particular statements in the Report should not be published unless permission has been previously granted by the Laboratory or the state station concerned.

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REPORT

of the

UNITED STATES REGIONAL PASTURE RESEARCH LABORATORY

For the Calendar Year 1943

INTRODUCTION

During 1943, emphasis was placed on those lines of research activity that seemed to promise most in the way of ascertaining facts or of producing plant materials which would be helpful in solving the pressing forage crop problems of the Northeastern United States, particularly those problems accentuated by the war. The greatest limitation to an expansion in the production of livestock products in the Region is a shortage of feed. During normal times ample stocks of concentrates from the Middle West are available to supplement those grown locally, but at present such feeds, particularly those high in protein, are not available in sufficient quantities. On most farms in the Region, this difficulty can best be alleviated, first, by growing forage crops with a high protein value and, secondly, by managing and harvesting these crops so as to assure a highly nutritious product, whether it be pasturage, hay or silage. Another difficulty arises from the fact that the available supply of seed of some well-adapted forage strains is limited. Of particular interest in connection with these present conditions are the results obtained during the year from pasture renovation to increase and give a better seasonal production of herbage (Pages 7 to 14), seed treatment with fungicides to control damping-off (Page 59), and the isolation by chemical methods of a proteinaceous substance from grass (Page 41).

Active cooperative research projects were carried on during the year with ten different state experiment stations in the Region. Detailed statements of progress on these projects may be found in the section below set aside for the purpose.

After a lapse of two years the Pasture Collaborators met in New York City July 27 and 28, 1943. A detailed account of the meeting was prepared and distributed to those attending the meeting, hence only a brief description will be incorporated here.

The present report is patterned after those prepared in previous years.

CHANGES IN PERSONNEL

Miss Marjorie R. Chambers, technical assistant in Plant Physiology and Chemistry, resigned June 21, 1943. A number of the greenhouse and field employes were inducted into the armed forces during the year, but thus far it has been possible to employ sufficient help to perform at least the more essential routine tasks.

PASTURE COLLABORATORS' MEETING

The meeting was held for the purpose of discussing changes in the research program of the Pasture Laboratory contemplated or initiated since the last meeting about two years ago and discussing effective means of increasing the supply of forage in the Region during the present emergency.

The pasture renovation experiments were discussed at some length. It seemed to be the consensus of opinion that this work would yield results of immediate practical value in increasing yields of forage in the Northeast. The proposed animal nutrition study with pasture plants, a cooperative project between the Pennsylvania Agricultural Experiment Station and the Pasture Laboratory, was outlined and some constructive criticisms offered. The chemical procedure followed in making a protein concentrate from grass or other plant material was described and samples of the concentrate were shown. Among other topics briefly discussed were plant reserves, effect of steam sterilization on soil productivity, fertilizer distribution and placement, nitrogen utilization, seed treatment to control damping-off, and breeding grasses and clovers. Some helpful comments made in regard to the further development of these lines of research have been mentioned in the report of the meeting and will not be repeated here.

Under the general topic, "Relation of Pasture Research in the Region to the War Effort", the Collaborators and others attending the meeting considered steps that might be taken to facilitate and increase forage production in the Region. A committee consisting of B. A. Brown, Chairman, Richard Bradfield, William G. Colby, and Fred V. Grau formulated a summary statement and made certain suggestions. This report was adopted by those attending the meeting and distributed generally in the Region.

The meeting was adjourned after two days of stimulating and mutually helpful discussions. Several delegates expressed the opinion that it was the most satisfactory Collaborators' meeting we have held.

COOPERATIVE RESEARCH BETWEEN STATE STATIONS AND THE LABORATORY

AGROSTIS TENUIS BREEDING (WITH RHODE ISLAND)

Title: Breeding Rhode Island Colonial Bentgrass for Pasture Types.

Leaders: For the Rhode Island Agricultural Experiment Station - Irene H. Stuckey.
For the Pasture Research Laboratory - W. M. Myers.

Most of the progress made with this work during the past season was in summarizing and evaluating the results obtained during the past two years.

Notes on the clonal plots showed that disease resistance is one of the most important characteristics in any final selection of an improved pasture strain. Silver top was present rather generally but no appreciable loss of seed was caused by this disease in 1943. Plots which seemed unusually desirable in June were almost completely destroyed by an epidemic of Helminthosporium in July and other plots which were not unduly damaged by this fungus, suffered severely from rust in August. Some selections appeared resistant to both diseases, and in addition had certain desirable pasture characteristics. New plots were started from these and from single spaced plants in the nursery. Some plots were planted to clones and others to seeds collected from open-pollinated material. In both cases the grasses were intersown with Ladino clover. Plants from some of the better clones were sent to the Pasture Laboratory for planting in isolation plots for the production of four new strains.

Herbarium specimens of bentgrasses from the nursery and from several native pastures in the Region were collected by Doctor J. R. Swallen*. It is hoped that eventually his findings can be correlated with the aberrant types and irregular chromosome numbers found in certain instances.

A report of preliminary studies of morphological and cytological variation in this species has been prepared for publication (Page 117).

* Division of Plant Exploration and Introduction, U. S. Department of Agriculture.

CHEMICAL COMPOSITION OF PASTURE GRASSES (WITH NEW HAMPSHIRE)

Title: The Chemical Composition of Pasture Grasses.

Leaders: For the New Hampshire Agricultural Experiment Station - T. G. Phillips and T. O. Smith.
For the Pasture Research Laboratory - J. T. Sullivan.

The analyses of timothy mentioned in the last report (1942 Annual Report, Page 5) have been completed, some additional determinations have been made, and the results have been published (Page 117) as Technical Bulletin 81 of the New Hampshire Agricultural Experiment Station. This concludes the work under the Adams Fund Project at the New Hampshire Station on the composition of timothy.

A new project at the New Hampshire Station entitled, "The carbohydrates of pasture and hay crops as related to their utilization by cattle", has been approved. The methods developed in the previous work will be applied to samples of grasses and hays whose digestibility and metabolizable energy have been determined.

DACTYLIS GLOMERATA, LOLIUM PERENNE, AND FESTUCA SPP. BREEDING (WITH MARYLAND AND DIVISION OF FORAGE CROPS AND DISEASES)

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass (Dactylis glomerata), Ryegrass (Lolium perenne, and L. multiflorum), and Fescue (Festuca spp.) Strains Adapted Particularly for Pastures in Maryland.

Leaders: For the Maryland Agricultural Experiment Station - V. B. Kemp.
For the Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture - M. A. Hein.
For the Pasture Research Laboratory - V. M. Myers.

Reduction in scientific personnel and labor supply, together with increased demands for other work of an emergency nature, has resulted in a program of marking time on much of the breeding work, so far as the Maryland Agricultural Experiment Station is concerned. The stocks of ryegrass and fescue are being carried pending later opportunity to renew active

breeding and testing. Mr. Paul R. Henson, project leader for the Division of Forage Crops and Diseases, has been assigned to other duties and has not been replaced. In view of the considerable importance of the program at the Plant Industry Station, an emergency plan has been arranged whereby the work can be continued on a reduced scale for the duration of the war. This plan involves the assumption of technical direction of the work on the Plant Industry farm by the project leader from the Laboratory in collaboration with Mr. M. A. Hein.

ORCHARD GRASS

Collection of Material. A nursery of approximately 2,000 plants to serve as further source of breeding material was established at State College, Pennsylvania, from open-pollinated seed of superior plants selected from the cooperative breeding nursery established in 1940 (1940 Annual Report, Pages 12 and 13).

Selection and Evaluation of Plants. There was a high mortality rate due to winterkilling among the plants in the polycrossing blocks (1942 Annual Report, Page 7) both at State College, Pennsylvania, and at Beltsville, Maryland. In general the surviving clones were the same at the two locations but some striking exceptions occurred. The highest mortality was among the clones of the late maturity groups; most of these clones were from plants selected from introduced strains, particularly those of the Welsh Plant Breeding Station. Seed was harvested from the surviving plants at Beltsville but none was obtained from the nursery at State College, Pennsylvania. The nurseries are being maintained and seed will be harvested in 1944 from both locations.

An additional 315 plants were selected from the space-planted breeding nurseries at State College, Pennsylvania, during 1943. These were increased vegetatively and planted in 15 replications in a polycrossing block.

Strain Trials. Considerable winter injury occurred in plots of some of the strains and single crosses seeded at State College, Pennsylvania (1942 Annual Report, Page 7). The two new strains compared favorably with the best of the strains and single crosses in winter survival. At the Plant Industry farm in the Uniform Nursery plots, the two strains produced from Maryland material (1940 Annual Report, Page 13) were outstanding compared with other orchard grass strains in establishment and persistence with Ladino clover during the first year.

New Strains. For the production of new strains, 21 isolation plots were established at State College, Pennsylvania, and five at Beltsville, Maryland, from selected plants differing in growth habit and maturity date. From three to 20 plants were used as a basis of each strain, these plants being similar in maturity and growth habit.

Inbreeding Studies. The inbreeding program at the Pasture Research Laboratory has been summarized elsewhere (Page 24). The 2,300 second inbred generation plants in the nursery on the University of Maryland farm were mowed when the seed was mature and selections were made largely on the basis of survival and recovery during the severe drought of summer and early fall. Only 78 plants were superior in this regard. These plants were transferred to the Plant Industry farm. It is planned to self these plants in the spring of 1944 to produce seed for an I_3 generation.

MICRO-CLIMATE STUDIES (WITH VERMONT)

Title: Micro-climate and the Growth of Several Pasture Species.

Leaders: For the Vermont Agricultural Experiment Station - G. P. Burns and J. V. Marvin.
For the Pasture Research Laboratory - V. G. Sprague.

Micro-climate Data. During the past year continuous data have been taken on several environmental factors including air temperature, soil temperature, relative humidity, precipitation, light intensity and soil moisture.

Species Tests. Using seed furnished by the Pasture Research Laboratory 100 small plots were established in the summer of 1943. These plots consist of twenty-five combinations of grasses and legumes in four replications. Combinations of orchard grass, bromegrass, reed canary grass and timothy with Lotus corniculatus, Ladino clover, sweet clover, red clover and alfalfa were used.

Data on survival and yields from these plots will be correlated with the climate data.

OVER-LIMING INJURY (WITH CONNECTICUT)

Title: A study of the Causes of Over-liming Injury to Pasture Species.

Leaders: For the Connecticut (Storrs) Agricultural Experiment Station - B. A. Brown.
For the Pasture Research Laboratory - R. R. Robinson and V. G. Sprague.

On some over-limed field plots at Storrs, boron deficiency of alfalfa was very prevalent in 1943 where borax had not been applied before seeding in August 1941. Borax at 40, 40 or 80 pounds per acre appeared equally effective in preventing

deficiency symptoms. Due to shorter, less vigorous alfalfa on the no-borax plots, those plots had less alfalfa and more volunteer grass. There were no appreciable differences in the results from over-liming with $Ca(OH)_2$ or $CaCO_3$ when applied at equivalent amounts of CaO.

In 1942, the alfalfa from the no-borax plots contained 25 p.p.m. of B, while borax at 20 pounds had increased it by over 40 per cent. From many analyses, it is concluded that alfalfa is not obtaining sufficient B from the soil when it contains less than 30 p.p.m. at the usual hay cutting stage.

In greenhouse trials with Charlton soil no appreciable amount of over-liming injury occurred even with excessive amounts of calcium carbonate (128 tons per acre). With hydrated lime very poor growth resulted where 15 tons or more per acre were applied. Apparently, however, this was due to the excessively high pH values obtained for a few days following liming.

PASTURE RENOVATION EXPERIMENTS (WITH CONNECTICUT)

Title: Grassland Renovation Trials in Connecticut.

Leaders: For the Connecticut (Storrs) Agricultural Experiment Station - B. A. Brown and R. I. Munsell.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

Procedure. Four seed mixtures were sown in the early spring of 1943 on quadruplicated 27.5 x 10 foot plots on each of five variously treated blocks of a 2-year old stand of timothy. Thus, a total of eighty plots were in the experiment.

The four seeding mixtures were:

1. Ladino clover.
2. Ladino clover and red clover.
3. Ladino clover and orchard grass.
4. Birdsfoot trefoil.

The five block treatments were:

1. Disked in fall of 1942.
2. Manured in fall of 1942.
3. None.
4. Atlacide in spring of 1943.
5. Sulphuric acid in spring of 1943.

The entire field was given a liberal treatment of limestone, superphosphate and muriate of potash in the fall of 1942.

All of the plots were cut with a tractor mower on May 27 and June 21 and the clippings were removed without weighing. On those dates, the species seeded in the spring of 1943 comprised but a very small percentage of the growth. On August 31, each plot was mowed, weighed and sampled separately to determine yields of dry matter. Before mowing, estimates were made of the percentages of area covered by each of the seeded species.

Results. On the disked block, Ladino clover or Ladino clover and red clover occupied about two-thirds of the plots on which they were seeded and especially the red clover had made a rather rank growth. This is supported by the fact that a ton or more of dry matter per acre was obtained on August 31 from each of the three Ladino clover seedings. A good stand of birdsfoot trefoil was also secured on the disked block but the yields were considerably less than secured from the Ladino clover seedings. Very little orchard grass was seen in 1943.

All of the other treatments resulted in much poorer stands and yields of the seeded species than the disking. There were no marked differences between the manured, non-treated, and the sulfuric acid treated blocks. The use of Atlacide for weakening the existing sod (largely timothy) allowed a somewhat better establishment of the seeded species than the use of manure or sulfuric acid.

PASTURE RENOVATION EXPERIMENTS (WITH MASSACHUSETTS)

Title: Grassland Renovation Experiments in Massachusetts.

Leaders: For the Massachusetts Agricultural Experiment Station - W. G. Colby.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

Work on this project was started in the fall of 1942 and the spring and summer of 1943 with the establishment of six renovation experiments--two in the eastern, two in the central, and two in the western part of the state. These experiments deal with pasture renovation by means of tilling, fertilizing, and reseeding, and include the use of top-dressed fertilizers. The following comments and observations appear worth recording at this time.

The first step in this method of pasture improvement is to kill or destroy all existing native vegetation. One of the objectives of these experiments was to determine the relative effectiveness of the "bog" or "brushland" harrow as compared to the plow in accomplishing this end.

Experience thus far indicates that in instances where the native vegetation is scanty and contains little grass, one thorough disking operation is as effective as plowing. This disking operation consists of half-lap working with a single disk in one direction and then cross disking at right angles once again half-lapping. Where a well-developed grass sod is present, one thorough disking operation is not sufficient. Seedings made following only one disking operation contained too high a percentage of native grasses to be considered entirely satisfactory. Better results were obtained when a thorough summer or early fall disking was succeeded by another working-over the following spring just prior to seeding. This provides an opportunity to rip out and further destroy live pieces of sod which had escaped destruction during the first operation.

Experience thus far with the bog harrow indicates that this machine may be considered as not so much a substitute for the plow but as an instrument which can be used to bring the benefits of tillage to large areas of land which are too rough and stony for satisfactory plowing.

The importance of controlled grazing management, particularly during the first grazing season, was graphically demonstrated on one experiment. The area was tilled, fertilized, and seeded in a satisfactory manner but when the time came for the first grazing, too many animals were turned on to it and they were allowed to remain there the rest of the summer. The result was a good stand of closely grazed grass with only a sprinkling of struggling clover plants. Grazing management practices on four other experimental areas were more favorable and in each case a good stand of clover resulted.

Previous experience has shown that unless satisfactory stands of the larger-growing legumes, such as Ladino clover, red clover, and alsike clover, are obtained the first year, it is questionable whether they can be secured without again tilling and reseeding. This point is important because the success of pasture renovation through reseeding depends almost wholly on the successful establishment of productive legumes, particularly Ladino clover.

PASTURE RENOVATION EXPERIMENTS
(WITH PENNSYLVANIA, AT MONTROSE,
AND
DIVISION OF FORAGE CROPS AND DISEASES)

Title: Pasture Renovation Trials in Northeastern Pennsylvania.

Leaders: For the Pennsylvania Agricultural Experiment Station - S. I. Bechdel.
For the Division of Forage Crops and Diseases - S. R. Skaggs and M. A. Hein.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

In the fall of 1942, a selected area in an old permanent pasture consisting of a rather thin sod of Kentucky bluegrass, Canada bluegrass, timothy and meadow fescue was limed, fertilized with phosphate and potash, and worked with a field cultivator. In the spring of 1943 various mixtures of grasses and legumes, including particularly those species which are larger-growing and deeper-rooted, were seeded on the previously worked areas. The same species were also seeded on the adjoining sod which had received the same lime and fertilizer as a top-dressing, but which had not been worked. No treatment "checks" were left in order to measure the effectiveness of the several treatments.

The following legume and grass species and mixtures were used:

Legumes	Grasses
1. Sweet clover.	1. Orchard grass.
2. Sweet clover and red clover.	2. Bromegrass.
3. Red clover and alsike clover.	3. Timothy.
4. Alfalfa.	4. Kentucky bluegrass.
5. Red clover, alfalfa and Ladino clover.	5. Bromegrass, timothy and orchard grass.
6. Ladino clover.	
7. Birdsfoot trefoil.	

Each of the seven legume species and mixtures was seeded alone and in combination with each of the five grass species and mixtures. The plots were laid out in a split-plot design using four replications.

The spring and early summer were favorable for the establishment of the new seeding. It also favored the growth of the sod which, due to excessive wet weather, had not been killed in the fall of 1942. In early July the whole area was mowed with a field mower set high and the top growth consisting largely of volunteer grass and weeds was removed. Late in August the recovery growth was lightly grazed and the remainder mowed and

the vegetation removed. A month later estimates of the legume stand on each plot were made to provide a basis for interpreting subsequent yields and persistence. The stand of all legumes on the cultivated area ranged from 15 per cent for birdsfoot trefoil to 81 per cent for sweet clover and the average stand for all legumes and legume mixtures was 66 per cent. On the uncultivated plots which had received the same amount of lime and fertilizer the average stand of all legumes and legume mixtures was 22 per cent. The stand of seeded grasses could not readily be estimated due to the volunteer grasses present and the limited growth made by the grasses which were seeded.

It is probable that a much better stand of birdsfoot trefoil and a slightly better stand of the other legumes and grasses would have been obtained if the existing sod had been more completely killed in the fall of 1942.

Dry weight yields and botanical estimates of the herbage obtained from the plots will be taken in 1944.

PASTURE RENOVATION EXPERIMENTS
(WITH PENNSYLVANIA, AT STATE COLLEGE)

Title: Pasture Renovation Trials in Central Pennsylvania.

Leaders: For the Pennsylvania Agricultural Experiment Station - A. W. Clyde and C. O. Cromer.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

In August 1942, a thin sod, composed predominantly of poverty grass, redtop, and moss with a small amount of Kentucky bluegrass and Canada bluegrass, was selected for use in investigating (1) the establishment and yield of some of the larger-growing and deeper-rooted grasses and legumes, (2) methods of seedbed preparation including the use of such implements as the field cultivator, the cover crop disk, the light disk and the mold board plow, and (3) fertilizer placement.

Grass and Legume Species Trials. The area selected for this purpose was limed and heavily disked in the latter part of August in an attempt to kill the existing vegetation. In early October, 200 pounds per acre of P_2O_5 and 200 pounds per acre of K_2O were broadcast and the area disked again. The following legume and grass species and mixtures were used:

Legumes	Grasses
1. Ladino clover.	1. Orchard grass.
2. Red clover.	2. Bromegrass.
3. Sweet clover.	3. Timothy.
4. Alfalfa.	4. Kentucky bluegrass.
5. Birdsfoot trefoil.	5. Orchard grass, bromegrass and timothy.
6. Red clover, alfalfa, and Ladino clover.	

Each of the six legume species and mixtures was seeded alone and in combination with each of the five grass species and mixtures. The plots were eight fe t square and laid out in a split-plot design with the grasses constituting the main plots and the legumes constituting the subplots. In addition to the seeded area, two strips eight feet wide and 192 feet long were not worked. One strip was limed and fertilized at the same rate as the disked area and the other strip was untreated. The former strip will indicate what improvement can be expected from fertilizer alone.

On March 30, 1943, the seed was broadcast and the area rolled once with a cultipacker since it was too late in the spring to expect freezing and thawing of the surface soil to adequately cover the seed. A good "catch" of all species was apparent in early May. In early July the entire area was mowed at three inches and the dry weight of herbage on each plot determined. Again on August 21, all plots except those of birdsfoot trefoil were cut and the yields determined. The plots that received neither seed nor cultivation were cut three times during the season with a lawn mower set at 1-1/2 inches. The total yields of dry matter on these plots were 757 pounds per acre for the untreated and 1205 pounds per acre for those receiving LPK. The total yields of dry matter from the plots on the disked, fertilized and seeded area ranged from 1016 pounds per acre for birdsfoot trefoil (only one clipping) to 2526 pounds per acre for the red clover plots with an average for all legume plots except birdsfoot trefoil of 2122 pounds per acre. There appeared to be little difference in yield in 1943 due to the seeded grasses.

The stands of legumes were estimated on August 3. Good stands of all legumes were obtained, ranging from 74 per cent for sweet clover to 87 per cent for red clover with the average stand of all species being 80 per cent.

Methods of Seedbed Preparation. An area adjacent to the above was used to study the adaptability of various tillage implements for working up the sod, the power and time required to obtain an adequate seedbed, and the subsequent establishment and growth of the seeded species on a seedbed so prepared. In general, the results of seedbed preparation indicated that a heavy disk was superior to the light disk, to the field cultivator, or to the field cultivator followed by the light disk. The light disk did not cut the sod sufficiently even when weighted and the field cultivator tended to roll the sod with consequent clogging of the cultivator. None of the above treatments was as effective as shallow plowing in killing the existing vegetation. The calculated drawbar horsepower hours per acre required were: Plowing, 12.5; heavy disking four times, 21.3; field cultivating four times, 25; and light disking two times followed with field cultivating two times, 20.3.

On March 30, 1943, all plots were seeded to a mixture of red clover, alfalfa, Ladino clover, orchard grass, bromegrass and timothy.

Plowing, although requiring the least time and power and being most effective in eliminating the existing vegetation had certain disadvantages. Although the area used was on only a very slight slope (three to five per cent), there was considerable evidence of sheet erosion during the winter on the plowed area but none on the disked area. Even more striking was the more rapid and vigorous establishment of the new seedings and their continued better growth throughout the season of the seeding year on the areas worked with a disk or field cultivator. The effects of dry weather were much more pronounced on the plowed area, due apparently to puddling of the soil surface by beating rains and consequent decreased moisture infiltration. Observations made during a heavy shower in August indicated greater water loss from the plowed plots.

Fertilizer Placement Studies. On the plots used for a study of tillage implements, several fertilizer placement treatments were used: (1) Lime, phosphate and potash were applied before any tillage; (2) lime was applied before tillage but the fertilizer was disked in later; and (3) lime was applied before tillage and the fertilizer was drilled in as the last operation. On the disked and cultivated areas, there appeared, in the seeding year, to be little effect of the method of applying fertilizer but on the plowed area the yield and stand of plants were better where the fertilizer was disked in as the last operation than where the fertilizer was plowed under or drilled in as a last operation. It should be emphasized that these results are only for the seeding year.

PASTURE RENOVATION EXPERIMENTS (WITH RHODE ISLAND)

Title: Pasture Renovation Trials in Rhode Island.

Leaders: For the Rhode Island Agricultural Experiment Station - B. E. Gilbert and Irene H. Stuckey.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

Two small demonstration areas were renovated in Rhode Island in 1942-43. The land was disked in the fall, limed immediately afterwards, fertilized in the spring at the rate of 800 pounds per acre of 0-14-14 and seeded.

The observations made throughout the summer were informative even if the gains were not so great as desired. Certain conclusions were reached which apply to both areas where pasture improvement was attempted.

1. Disking in the fall did not eliminate existing vegetation sufficiently to prevent serious competition with the seeded species during the year of seeding.

2. Certain species, especially orchard grass, Ladino clover, and red clover, were readily established. However, it remains to be seen how persistent they will be.

3. Other species, i.e., bromegrass and birdsfoot trefoil, were virtually non-existent, perhaps due to competition, perhaps to other factors.

4. Weeds were obnoxious in both areas.

Renovation was begun at another location during the fall of 1943. This land had not been limed for at least forty years and was gradually reverting to brush. To date, the brush has been cut and the land thoroughly torn up to prepare a suitable seedbed.

PASTURE RENOVATION EXPERIMENTS (WITH VERMONT)

Title: Pasture Renovation Trials in Vermont.

Leaders: For the Vermont Agricultural Experiment Station - A. R. Midgley and D. E. Dunklee.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

The objectives of these studies are: (1) To determine methods of increasing the yield of forage without increasing the number of acres used for pasture, (2) to determine methods of producing more uniform distribution of feed throughout the summer months, (3) to study the adptability for pasture purposes of various mixtures of grasses and legumes especially the deeper-rooted, taller-growing hay-type plants, (4) to compare yield data from renovated areas with those receiving similar fertility treatments but without tilling and seeding, and (5) to determine the relative responses to fertilizer placement such as broadcast vs. drilling.

Typical run-down pasture areas on three distinct soil types are being used in this study. The land was limed, disked and fertilized during the fall of 1942 and seeded in early spring. The following grass-legume mixtures were used: Ladino clover and orchard grass; sweet clover and reed canary grass; alfalfa and bromegrass; red clover, alsike clover and timothy; sweet clover and tall oat grass; birdsfoot trefoil and timothy.

An ordinary disk was used on these run-down pastures and a rather poor job was done in destroying the original vegetation, yet sufficient bare ground was exposed for seeds to germinate

and good stands were established in most instances. About September 1, representative areas were cut with a hay mower to obtain yields, after which they were grazed. The yields obtained on one of the heavier soil types are shown below:

	Pounds of Dry Matter Per Acre
Red clover, alsike clover and timothy	2160
Ladino clover and orchard grass	1980
Sweet clover and reed canary grass	1900
Alfalfa and bromegrass	1630
Birdsfoot trefoil and timothy	894
Fertilizer only, no seed	880
No treatment, original sod	236

Somewhat similar responses were obtained on the very light soil type although the actual yields were much smaller. No outstanding differences have yet been obtained between broadcasting or drilling the fertilizer in these trials.

Since starting these trials, a heavy cutaway disk harrow has been purchased and it is planned to increase the number of renovation experiments.

POA PRATENSIS BREEDING (WITH PENNSYLVANIA)

Title: Breeding Kentucky Bluegrass for Improved Pasture Types.

Leaders: For the Pennsylvania Agricultural Experiment Station - J. K. Thornton and S. I. Bechdel.
For the Pasture Research Laboratory - W. M. Myers.

Collection of Source Material. No additional material was collected during the past year. It is planned to discontinue growing new space planted breeding nurseries (except for promising new strains from other experiment stations) at least until the strains that are now on hand have been evaluated.

Progeny Uniformity Tests. Records were taken on the progeny uniformity tests established in the fall of 1941 and the spring of 1942. Seed was harvested from the progenies that were sufficiently uniform. Also panicles were harvested from 45 selected plants from variable progenies and these were included in further progeny tests planted in the fall of 1943. Sixty-three plants were selected from the sod plugs collected from old pastures in Pennsylvania and West Virginia in 1941 (1941 Annual Report, Page 11) and progeny tests of these plants were established in the fall of 1943.

Seed Increase. One of the five strains that were being increased (1942 Annual Report, Page 9) was discarded because of lack of uniformity. From 15 to 21 pounds of seed were obtained from the other four. Further increase of two of these strains was planned but, due to the drought in the fall of 1943, planting was postponed until the spring of 1944.

Advanced Plot Trials. Clipping weights were taken during the spring and summer on the plots of 25 strains (1941 Annual Report, Page 12). Leaf spot has seriously reduced the stands of many of the strains and it was decided to discontinue these plots at the end of 1943. Two strains continued to be outstanding in performance. The results of another advanced plot trial have been summarized elsewhere in this report (Page 26).

Plans have been developed for seeding replicated pasture plots (to be grazed by dairy cows) of the four new strains of which seed has been increased. A commercial seed lot will be included in the planting to serve as a check.

POA PRATENSIS AND TRIFOLIUM REPENS BREEDING (WITH WEST VIRGINIA)

Title: Breeding and Improvement of Pasture Grasses and Legumes.

Leaders: For the West Virginia Agricultural Experiment Station - E. J. Wellhausen, R. O. Weibel, J. G. Leach, and Conley Lowther.
For the Pasture Research Laboratory - V. M. Myers (Kentucky Bluegrass) and S. S. Atwood (White Clover).

No additional material in the way of collections from the state or other sources was added to the nursery in 1943.

Most of the work in 1943 was devoted to a more thorough study of the Kentucky bluegrass material being grown. An attempt was made to classify the material in the original nursery and the 1942 progeny test on the basis of type. A classification into types would be a useful tool in studying their behavior and characteristics.

A germination study of selected strains of Kentucky bluegrass from the original nursery was started. Seed of these selected strains were germinated under different temperature conditions to check response. This study showed that there are differences in response but further study is needed to check results.

The Kentucky bluegrass material seeded in small plots (3 ft. x 12 ft.) in 1942 (1942 Annual Report, Page 10) was very slow in establishment. Some plots were reseeded where stands were very poor. The clover stand was also somewhat irregular. Differences in behavior of the grass strains in association with the white clover should begin to become evident in 1944.

Notes on the breeding behavior of the plants selected for the progeny test in 1943 show that of the 229 plant rows observed approximately 30 per cent of the rows were breeding true (Table 1). Forty per cent of them had aberrant plants of from one to ten per cent.

Table 1. Percentage of plants showing indicated frequencies of off-type progenies.

	Classes in Per Cent Aberrants								
	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Percentage of the plants falling in the above classes	30	40	10	8	6	3	0	2	0.4

When the strains were grouped as those originating from good, medium and poor pastures (not all of the strains were classified), the results obtained were as indicated in Table 2.

Table 2. Growth behavior of the strains included in the 1942 progeny test when classified as originating from good, medium and poor pastures.

Per Cent of Aberrants	Per Cent of Strains from Pastures When Classified as to		
	Good	Medium	Poor
0	36	30	26
1-10	42	34	41
11-20	4	15	9
21-30	8	9	6
31-40	6	3	11
41-50	2	8	1
51-60	2	0	0
61-70	0	0	3
71-80	0	0	1
No. of strains	52	73	94

Smut notes are incomplete but where reported approximately 33 per cent of the strains in the progeny test showed smut with percentages ranging up to as much as 77 per cent of infected plants. The results

obtained when the strains were grouped as originating from good, medium, and poor pastures (not all the strains were classified) are shown in Table 3.

Table 3. Percentage of strains from good, medium, and poor pastures showing indicated percentages of smutted plants among their progenies.

Per Cent of Smutted Plants	Per Cent of Strains from Pastures When Classified as to		
	Good	Medium	Poor
0	83	71	60
10	17	22	30
20	0	0	4
30	0	7	1+
40	0	0	1+
50	0	0	0
60	0	0	1+
70	0	0	0
80	0	0	1+
No. of strains	18	41	67

Seed was harvested from many of these rows for use in future studies.

An additional progeny test of 40 plants each from 197 individual plant selections made in 1941 was established in the field in the spring of 1943.

Experimental inoculation of bluegrass was made with smut, Ustilago striaeformis, with the view of developing a suitable technique for testing selections for smut-resistance. Several different methods of inoculation were used but very low percentages of infection were obtained in all attempts. In one small experiment, 25 per cent of the plants were infected, the highest infection obtained. Poor infection is believed due to poor germination of the spores as all collections used germinated poorly in all germination tests.

Thinking that a higher percentage of infection might be obtained if the fungus could be obtained in artificial culture, isolation of the fungus was undertaken. After numerous unsuccessful attempts to isolate the fungus from spores obtained from mature sori and germinated in hanging drops, it was successfully isolated from spores taken from immature sori and from tissue cultures made from young tissue adjacent to immature sori. Several growth types were obtained and some of the cultures produced chlamydospores in culture.

Inoculation experiments with vegetative mycelium and spores from artificial culture are under way but the results are not yet conclusive.

Studies on the cytology and genetics of the fungus are under way. Plans have also been projected for a study of methods of infection and factors influencing infection.

TRIFOLIUM REPENS BREEDING (WITH NEW JERSEY)

Title: Breeding White Clover for Pastures.

Leaders: For the New Jersey Agricultural Experiment Station - G. H. Ahlgren.
For the Pasture Research Laboratory - S. S. Atwood.

Progeny Test of Diallel Crossing System. The planting of the last replication in the progeny test was completed in 1942. The methods and techniques used are described in the 1940 Annual Report, Page 15. The planting of this test had been extended over the 3-year period, 1940 to 1942, inclusive, due to the large number of plots necessary to test almost 190 crosses. Selections of parents having superior combining ability as based on the progeny test were completed on the 1940 planting in 1941 and were found to be 6-3, 6-9, 6-10, and 6-16. No selection of superior plants was made in 1942 but the past season (1943) has provided additional information on the second replication planted in 1941 consisting of 140 row plots of seven plants each and representing over 60 crosses. The superiority of a parent is based on the number of times it enters into combinations producing superior progeny. On the basis of uniformity, vigor, freedom from disease, height of petiole, and other characters, four parents known as 6-4, 6-5, 6-6, and 6-15, were judged superior in the 1941 planting. Some data have been accumulated on the 1942 planting and this will be further supplemented next summer. Conclusions on the first and second replications planted in 1940 and 1941 are given in Table 4.

It is interesting to note that the eight parent plants now judged superior for combining ability are originally from four families: The parents having the Pasture Research Laboratory Nos. 6-3 and 6-4, or New Jersey selections 3-20 and 3-23, originated from a seed lot collected in an old pasture near Somerville, New Jersey. Pasture Research Laboratory identification Nos. 6-5 and 6-6 are New Jersey Nos. 19-2 and 19-7 and came from a seed lot collected from an old pasture at Bedminster, New Jersey. The Pasture Research Laboratory Nos. 6-9 and 6-10 are New Jersey selections Nos. 36-23 and 36-38 also having come from an old pasture in the vicinity of Somerville, New Jersey. Pasture Research Laboratory Nos. 6-15 and 6-16 represent New Jersey Nos. Mo. 6 and Mo. 33 and originated from a seed lot supplied by the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture. The parent plant 6-15 also known as Mo. 6 has been noted for its particularly vigorous and aggressive growth since it was first brought under observation in 1937. The twenty parent plants used in these diallel crosses are being maintained

for further breeding work as soon as final selection of parents is made. In addition, vegetative cuttings have been taken from plants produced by the superior parents and these are being maintained for further study in the breeding program.

Table 4. Further evaluation of parent plants used in the diallel crossing system.

New Jersey No.	Pasture Research Laboratory No.	No. of Crosses or Reciprocals in Which Parents Appear	No. of Superior Crosses or Reciprocals in Which Parents Appear
3-10	6-1	17	3
3-12	6-2	19	4
3-20	6-3	15	4*
3-23	6-4	16	5*
19-2	6-5	17	5*
19-7	6-6	19	6*
27-5	6-7	17	3
36-21	6-8	11	3
36-23	6-9	10	4*
36-38	6-10	18	8*
36-44	6-11	10	0
36-49	6-12	12	1
Dixie 13	6-13	18	2
Mo. 5	6-14	16	4
Mo. 6	6-15	20	6*
Mo. 33	6-16	19	8*
Ladino 6	6-17	16	2
Ladino 14	6-18	12	1
Ladino 18	6-19	16	3
Ladino 42	6-20	14	0

* Judged a superior parent on basis of present progeny test.

Continuous Selection from Six Isolated Open-pollinated Strains. Approximately 200 plants are available for further study, selection and seed production by this method of breeding which is being compared to the diallel system. It is expected to transplant these plants to the middle of a corn or soybean field for isolation from other wild or native white clovers. Inferior individuals will be eliminated and superior plants allowed to cross freely and seed collected again.

Drought-resistance Study. The greenhouse wilting experiment was continued in 1943 in an attempt to devise a method for obtaining information on resistance of white clover plants to internal desiccation. The wilting method used was to remove all top growth periodically, bring the jars to a uniform weight by

adding water, and then permit wilting of newly developing leaves for various lengths of time until all plants were destroyed.

Plants from the crosses (Del3X3-12) and (Del3XLal4) formed the basis for this study. The method described above was continued until only three plants from the (Del3X3-12) cross remained alive. While it has been possible to get differential destruction of plants by this technique the results are questionable due to the different behavior of replications of the same plant and the inability to maintain uniform clover growth on the respective replications. If this difficulty could be solved the technique would appear to have merit.

TRIFOLIUM REPENS, TRIFOLIUM PRATENSE AND PHLEUM PRATENSE BREEDING (WITH NEW HAMPSHIRE)

Title: The Improvement of Ladino Clover, Red Clover and Timothy by Selection and Breeding.

Leaders: For the New Hampshire Agricultural Experiment Station - Ford S. Prince, L. J. Higgins, and Paul T. Blood.
For the Pasture Research Laboratory - S. S. Atwood (Ladino Clover and Red Clover) and W. M. Myers (Timothy).

Ladino Clover. Plants selected from the F_2 generation were back-crossed to Ladino plants secured from established stands. This was done in the winter and spring of 1943. From these crosses 600 seedlings representing about 30 families were produced and set at Greenland.

Seedlings were also produced from seed secured from caged plants in the summer of 1942. Twenty-five seedlings from each of 16 mother plants were set in our nursery in May and June.

These plantings were scored in September and the best breeding stock was determined by this method, supported in part by observation. Twenty plants were selected representing Ladino parentage, F_1, F_2, and F_3 generations as well as caged progeny. All of these have been brought into the greenhouse for multiplication. Nine of the best will be used as the basis of a new strain, but all 20 will be tested for their suitability as to competition with grasses, their ability to persist under different systems of management, and for their yielding ability. By means of this testing process we may be able to make further improvements in the strain during succeeding years.

Red Clover. Twenty-four seedlings have been brought into the greenhouse for crossing this winter. These seedlings represent the more persistent families of the original lot of twelve which were seeded

in 1939 and have stood in the field through four full seasons, and include also some of the plants representing the F_1, and F_2 generations produced by intercrossing.

Seed was harvested in the summer of 1943 from the plants that remain in the 1939 seeding. This will be used again for multiplication and testing. Seed was produced in 1943 from the first planting sown in 1942. Some of this also is available for testing, both in controlled work and on farms.

Timothy. Two strains of timothy, one late hay type and one showing certain characteristics suited to grazing, are being carried along. These originally were propagated clonally from parent material in the nursery. The clonal rows are still intact although a few less desirable ones are being weeded out as the work progresses.

Multiplication plots of each were seeded in 1943 for purposes of seed production. Bulked seed was used for this purpose. In addition, seed of each plant was planted in small duplicate plots for purposes of testing, both for yield records and for persistence under clipping.

RESEARCH AT THE LABORATORY

CYTOGENETICS AND BREEDING OF GRASSES

Fertility Studies in Dactylis glomerata and Festuca elatior

Variation and Inheritance of Ability to Set Seed under Bag in Dactylis glomerata. The investigations described previously (1942 Annual Report, Page 16) have been continued. For studies of the range of self-fertility among plants of strains, commercial seed lots, and collections from natural populations, the plant material collected for the cooperative breeding program (1940 Annual Report, Pages 12 and 13) was used. Data were obtained on number of seeds per panicle set under bag and with open-pollination from an average of 14.5 plants from each of 19 introduced strains and one commercial seed lot. There was a greater range among plants within strains than between means of strains. Nevertheless, there were differences among strains in self- and open-pollinated seed set as well as in self-fertility (selfed seed set expressed as per cent of open seed set).

In the material collected from pastures, fields and roadsides in Maryland and Virginia, there was variation in fertility among plants within collections and among collections. There was some indication from the data that the plants collected from pastures were more self-fertile on the average than those from the introduced strains or from commercial seed.

In studies of the I_2 (second inbred generation) progenies of selected I_1 plants from three families, further evidence was obtained of the heritability of differences among plants in number of seeds per panicle set under bag and with open-pollination and in per cent seed set. There was a decrease in fertility from I_1 to I_2 similar in magnitude to the decrease from parent to I_1 encountered previously (1941 Annual Report, Page 19). The average of the I_2 progenies in number of seeds per panicle set under bag ranged from 8 per cent to 74 per cent of the seed set of the I_1 clone. As an average of all progenies the seed set under bag of the I_2 was only 23 per cent that of the I_1 clones. The seed set with open-pollination of the I_2 progenies was 41 per cent that of the I_1 clones, indicating a decrease in female fertility of the plants. This may have resulted from reduced panicle size (fewer florets per panicle), reduced fertility of the florets, or a combination of these factors. There was evidence also of a decrease in self-fertility, i.e., selfed seed set as per cent of open seed set. The average percentage seed set of the I_1 clones was 22 per cent compared with 10 per cent for the I_2 progenies. A paper summarizing these results was presented before the meetings of the American Society of Agronomy in November 1943 (Page 70).

Inheritance of Male Sterility in Dactylis glomerata. More than 95 per cent of the plants placed in the field in the fall of 1942 for the study of this problem (1942 Annual Report, Page 16) were killed during the winter of 1942-43. Since insufficient reserve seed of these crosses was available, the crosses are being repeated in the greenhouse in the winter of 1943-44 and the nursery will be re-established in the spring of 1944.

Variation in Ability to Set Seed under Bag in Festuca elatior. The number of seeds per panicle set under bag was determined for 257 selected plants of the diploid meadow fescue. In general self-fertility was low. A majority of the plants set less than one seed per panicle and the maximum number of seeds per panicle was 12.

Varietal Improvement of Dactylis glomerata, Festuca elatior, Poa pratensis, Sorghum vulgare var. sudanense and Bromus inermis

Most of the investigations relating directly to the improvement of orchard grass and Kentucky bluegrass have been incorporated in the cooperative breeding projects with these species and the report of these investigations has been presented in that section of the Annual Report (Page 3).

Evaluation of Plant Types. Observational data were taken at several times during the growing season on the preliminary plots of Kentucky bluegrass strains (1942 Annual Report, Page 17). Significant differences among strains were observed in earliness of growth in the spring, amount of growth, type of growth, density of sod, percentage of white clover, recovery following clipping, and resistance to leaf spot. Differences in growth and succulence were particularly striking during the severe drought of midsummer and fall.

Inbreeding in Dactylis glomerata. The unusually severe winter-killing during the winter of 1942-43 resulted in the loss of large numbers of the inbred plants established in the field in the fall of 1942. In many cases, entire inbred progenies were killed and in a few instances all of the inbred lines of a family were lost. There were striking differences among families in winter survival, indicating distinct heritable differences in this character. Reserve seed was available for replanting a majority of the lines in the spring of 1943. Where reserve seed was not available, the I_2 clones were planted in pots in the greenhouse and additional selfed seed will be obtained.

Inbreeding Studies in Sorghum vulgare var. sudanense. On the basis of their yield in last year's clipping trial and their disease resistance in both mature plant and clipped rows, 50 lines were selected for further inbreeding in 1943. Because

the seed of some of these lines had been damaged by the early frost in 1942, poor stands were obtained in 1943. It was not possible, therefore, to obtain as much selfed seed as desired from them. Continuation of these lines will be dependent on the amount of new seed obtained in 1943 and the remnant seed available from 1941.

Since the Tift strain had yielded better in 1942 than any of our selfed selections (1942 Annual Report, Page 18), about 2,000 individual plants from commercial Tift seed were grown in 1943. Before the heads emerged, about 200 plants of diverse types were selected, and all of these were bagged. Late in September when the mature plant characters were more obvious and when disease had developed in some plants, detailed notes were taken on all selected plants, and 48 of them were chosen as possible desirable pasture types from which new inbred lines will be started.

Natural Crossing in Sorghum vulgare var. sudanense. In 1942 six rows homozygous for red color and six breeding true for absence of color were planted in isolation in pairs according to relative maturity date. Most of the seed was badly frosted, but a progeny of 677 open-pollinated plants from the recessive parents was obtained for classification in 1943. Only 124 of these plants showed the red color of the dominant parent, indicating crossing of 18.3 per cent. This is considerably less than was obtained in 1942 (1942 Annual Report, Page 18).

A new isolation block was grown in 1943, and it is expected to grow a much larger progeny for classification next year.

Yield Trials of Inbred Lines in Sorghum vulgare var. sudanense. The 50 lines selected for further inbreeding (mentioned under "Inbreeding Studies") were grown in three replications for a clipping trial similar to the ones made in 1942 (1942 Annual Report, Page 18). Three samples of commercial Tift seed were sown as checks. Here also poor stands developed with several of the lines, so only 25 were finally used. Highly significant differences between lines were obtained in each of the four cuttings and in total yield. The three lots of Tift ranked 1, 2, and 4 in total yield, but several other lines fell within the ranges of the least significant differences for each cutting and total yield. The best total yield was 1249 grams, and the poorest was 530.

Method of Reproduction in Poa pratensis. The method of reproduction of 115 selected plants of Kentucky bluegrass was measured by the progeny test, using 20 plants from open-pollinated seed in each test. Most of the plants were selected from sod plug isolations from old pastures in Pennsylvania. The relative frequencies of apomictic and partially sexual types (Table 5) are similar to those obtained previously from material from other sources (1939 Annual Report, Page 14; 1940 Annual Report, Page 18).

Table 5. Number of first generation progenies of Kentucky bluegrass showing indicated percentages of off-type plants.

Per cent Off-type	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total
No. of plants	25	50	23	6	5	0	2	1	0	1	1	114

Second generation progeny tests of first generation plants from two families yielded results similar to those obtained previously (1942 Annual Report, Page 19). Off-type first generation plants produced, on the average, more variable progenies than their parents or parental type sibs. Occasional first generation plants which were classified as parental type on the basis of morphology were shown by their breeding behavior to be variant type plants.

Strain Trials of Poa pratensis. The experiment described previously (1942 Annual Report, Pages 19 to 23) was continued. Three clippings were made during 1943. The early clipped plots were harvested on May 15, June 10, and August 2, while the deferred clipped plots were harvested May 19, June 10, and August 2. The severe drought retarded growth so much that additional clippings could not be made.

The results were generally consistent with those obtained in 1942. Differential seasonal distribution of yield was shown by the strains. The differences among strains were relatively large at the first and third clippings and small at the second clipping. One strain yielded more total dry matter than the better of the two commercial checks while three others yielded nearly as much as that check. KB143(223) was again the highest yielding strain, its superiority being particularly evident at the third clipping.

The early clipping treatment produced the higher yield at the second date and as a total for the season while the deferred clipping treatment was superior at the first and third dates. Strain x clipping treatment interaction was not significant for yield at any date of clipping. The clipping treatment was not significant so far as incidence of clover was concerned, but the strain x clipping treatment interaction was significant ($P > 0.01$) for per cent of clover at the August 2 clipping. This is the first evidence obtained in this experiment of a differential effect of clipping treatment on the incidence of white clover in the plots.

Response of Strains of Poa pratensis to Nitrogen Fertilization and Association with Trifolium repens. For these investigations, eight selected strains of Kentucky bluegrass differing in growth

habit, type of sod, seasonal distribution of yield, and companionability with white clover were used. These will be tested with and without white clover and with and without nitrogen fertilization. A split plot design was used with the clover vs. no clover as the main plots, nitrogen vs. no nitrogen as the first sub-plots and strains as the second sub-plots. Four replications were used. These plots were seeded in the fall of 1943 and will be clipped uniformly for establishment during 1944.

Production of Improved Strains of Festuca elatior. From the meadow fescue collected and planted in the nursery during the fall of 1941 (1942 Annual Report, Page 23), 120 plants were selected on the basis of vigor, leafiness and other characters of agronomic importance. These were classified into 15 groups as regards maturity date and growth habit. The plants were increased vegetatively and each group was transplanted in the fall of 1943 to an isolation plot where the plants will be permitted to interpollinate for the production of new strains.

Inbreeding in Festuca elatior. Among the 257 plants of meadow fescue that were self-pollinated in the spring of 1943, several produced sufficient seed for the establishment of a first inbred generation. Of these, 25 were selected and 30 inbred plants from each were transplanted to the nursery in the fall of 1943. Plants of the parental clone were placed in the row adjacent to the inbred progeny in each instance.

Collection of material of Bromus inermis for the establishment of a breeding nursery. Seed of strains, local collections and selected plants was obtained from eight experiment stations in the United States and one station in Canada. In addition, several collections were made from wild stands in Pennsylvania. From this material, a nursery of approximately 5,000 individually spaced plants was established in the fall of 1943.

Production of New Strains of Bromus inermis. A nursery of a few hundred spaced plants from bromegrass of Nebraska origin was made available to the Laboratory for plant selections by the Department of Agronomy, of the Pennsylvania Agricultural Experiment Station. Extreme variation was found among the plants. Nineteen plants of four growth habit classes were selected from this material, increased clonally, and transplanted to four isolation plots for the production of new strains.

Genetical Investigations

Heritable Young Plant Characters in Dactylis glomerata. As a result of poor growth and heading in the greenhouse during 1942-43, it was possible to make only a small portion of the crosses that were planned (1942 Annual Report, Page 24). Seedlings have been

started in the greenhouse from about 100 crosses. In most cases involving mutant types from different inbred progenies, the F_1 has been normal, indicating different genes conditioning the character. Additional crosses will be made in the winter of 1943-44.

Inheritance in Phleum pratense. The genetical investigations reported previously (1941 Annual Report, Page 20) are being continued. Over 1,000 plants from several hundred selected I_2 progenies were self-pollinated during 1943. A majority of the plants produced sufficient selfed seed for a progeny test. These seedling progenies (I_3 generation) are being grown and classified in the greenhouse during 1943-44.

Interspecific hybrids in Poa. Seed was collected from selected F_2 plants from the cross Poa compressa x P. pratensis. F_3 progenies were established in the field in the fall of 1943.

Cytological Investigations

Meiotic Irregularity in Dactylis glomerata. Investigations of the effects of inbreeding upon meiotic irregularity in orchard grass (1942 Annual Report, Pages 29 to 32) have been continued using plants of two I_2 progenies from selected I_1 plants. The results obtained in one of these families are presented in Table 6. The average quadrivalent and chiasma frequencies of the I_2 progenies were the same as for the I_1 clone. On the other hand, the average percentage of metaphase I sporocytes with univalents was 17.5 for the I_2 compared with 4.6 for the I_1 clone. Similar results were obtained for the other I_2 progeny. These results are consistent with those obtained from the I_1 generation (1942 Annual Report, Pages 29 to 32), indicating that an increase in meiotic irregularity accompanies inbreeding in orchard grass. A paper summarizing these results was presented before the meetings of the American Society of Agronomy in November 1943 (Page 70).

Table 6. Average number of quadrivalents per sporocyte, chiasmata per chromosome and percentage of metaphase I with univalents of 12 I_2 plants and their I_1 parental clone.

Plant No.	Average Number of IV	Average Number of X-ta	Percentage of MI with Univalents
1	4.5	1.8	4.4
2	4.3	1.9	8.2
3	4.6	1.8	9.5
4	3.7	1.8	11.5
5	4.2	1.9	15.6
6	4.4	1.9	15.8
7	3.9	1.8	18.2
8	4.0	1.8	22.2
9	3.8	1.8	23.5
10	4.4	1.9	24.7
11	3.4	1.9	26.3
12	5.3	1.8	30.2
Average of I_2	4.2	1.8	17.5
I_1 clone	4.2	1.9	4.6

Chromosome Numbers in Festuca elatior. Because of the occurrence of races of Festuca elatior different in chromosome number (1942 Annual Report, Page 32), determinations of chromosome numbers of meadow fescue plants collected from local habitats in central Pennsylvania have been continued. Seedlings obtained from seed collected from two plants of meadow fescue found growing near State College, Pennsylvania (seed collected by Professor J. K. Thornton, of The Pennsylvania State College) were found to be hexaploid (2n = 42). This area has not been cultivated or seeded in recent years and no information is available regarding the original source of the plants growing here. This is the first case reported of meadow fescue plants collected from the wild in the United States with chromosome numbers of other than 2n = 14.

Distribution of Chromosomes at Anaphase I in Autotriploid Lolium perenne. It has been assumed generally that the third set of chromosomes of triploids are distributed at random during meiosis except for the loss due to lagging. Consequently, it is expected that gametes will be produced with chromosome numbers ranging from haploid to diploid in an approximately binomial frequency. This hypothesis has been tested with adequate data in only one instance. Satina and Blakeslee, working with triploid Datura stramonium (X = 12), found an excess of 12-24 to 15-21 distributions and a deficiency of the 17-19 and 18-18 assortments compared with frequencies expected on the basis of random distribution.

The hypothesis was tested using plants of autotriploid perennial ryegrass. It was determined by calculation that position of the univalents at metaphase I relative to the equatorial plate and to one another would affect anaphase I distribution; the frequencies of different distributions at anaphase I would agree with the binomial frequencies only if the positions of metaphase I univalents were random. In 2494 metaphase I sporocytes, the positions of the univalents relative to one another and to the equatorial plate were random. The distribution of chromosomes in 1636 anaphase I sporocytes was consistent with the assumption of chance position of the metaphase I univalents and random assortment of the extra chromosomes of the trivalents.

The behavior in triploid Lolium perenne differs from that found in triploid Datura stramonium by Satina and Blakeslee. These results have been presented for publication (Page 70).

Colchicine Induced Autotetraploids in Festuca elatior. Using the technic described previously for perennial ryegrass (1938 Annual Report, Pages 33 to 37), 2x-4x chimeral seedlings of meadow fescue were obtained from germinating seeds treated with an 0.2 per cent solution of colchicine for 24 hours. When the seedlings were taken at random, only four out of 69 were chimeras; the remainder were normal diploids. At a later date from seeds treated in a similar manner, only abnormal appearing seedlings were selected for transplanting to pots. Of these, 39 out of 66 plants were chimeras. After two generations of vegetative increase using single tiller isolations in each case, many of the plants are still chimeras. These results are consistent with those obtained from clones of perennial ryegrass (1942 Annual Report, Pages 28 and 29).

CYTOGENETICS AND BREEDING OF LEGUMES

Fertility Studies in Trifolium repens

Genetics of Self-compatibility. In order to test further the self- and cross-compatibility relations of certain plants which had given anomalous results in the field (1942 Annual Report, Page 32), 150 selected individuals were self-pollinated and were cross-pollinated with appropriate testers last winter in the greenhouse. Although the results were not absolutely decisive, it is felt that no additional work need be planned for this problem at the present time.

As a part of this investigation, there were isolated several plants which proved homozygous for the self-compatibility factor. These plants are now being utilized extensively in the practical problem of obtaining inbreds, as explained later in this report (Page 34).

Number of Alleles Causing Cross-incompatibility. The phase of this problem which was investigated most extensively during the past year was concerned with the frequency of alleles in natural populations. The study was begun in 1941 when selections were made in two locally-confined pasture areas in central Pennsylvania (1942 Annual Report, Page 33). The smaller of the two areas was an isolated mountain pasture in which the total white clover population was estimated at only a few thousand individuals; the larger area consisted of a group of bottomland pastures where the total population was estimated as a few hundred thousand individuals. From each of these two populations, 49 plants were finally chosen. In the greenhouse each of these plants proved self-incompatible and cross-compatible with an individual homozygous for oppositional alleles (S_1S_1). From each resultant F1 progeny, one plant was selected, and diallel crosses were made between the 49 F1 plants within each series. Incompatible matings among the diallel crosses indicated that the two unknown alleles were identical, whereas compatible matings indicated they were different. In this way the frequency of the different alleles was determined for each of the populations (Table 7).

In the first series, 36 (73 per cent) of the 49 alleles were different, resulting in 1.53 per cent of the matings being incompatible. In the second series, 39 (80 per cent) were different, resulting in only 0.94 per cent incompatible crosses. Considering the two populations together, 58 per cent of the alleles occurred in only one plant, and none of them were found in more than four. In the larger population, where the sampling was carried out in nearly linear order throughout the greatly elongated area, some evidence was obtained for local inbreeding within sub-populations. Within neither of the series was there any difficulty in distinguishing compatible from incompatible matings. The former averaged 37.3 and 38.1 seeds per head, respectively, in the two series, while the latter averaged 0.72 and 0.81. In neither series did the range in seed set from these two types of crosses overlap.

More crosses were made per plant in this study than in any previous one. It was concluded from the analyses that these plants differed significantly in their seed setting ability as females, but as males the differences between the same plants were questionable, especially among those with no obvious morphological defect.

In this study, the first case was found for white clover of a plant being highly male sterile due to other than morphological causes. The pollen of this plant appeared normal in both size and stainability, and preliminary cytological examination of the microsporocytes showed no irregularities.

The results of this study have been submitted for publication (Page 70).

Table 7. Frequency of different alleles in two natural populations of white clover.

	No. of different alleles each of which occurred in the following number of F1 plants				Total alleles tested	Total different alleles	Per cent different alleles
	1	2	3	4			
1st series (smaller)	27	6	2	1	49	36	73
2nd series (larger)	30	8	1	0	49	39	80
Total	57	14	3	1	98	75	77

Behavior of Oppositional Alleles in Polyploids. When preliminary tests had shown that the 64-chromosome sectors of white clover were self-incompatible like the 32-chromosome plants from which they arose (1942 Annual Report, Page 38), two corresponding F_1 progenies derived from two sets of comparable 32- and 64-chromosome parents were selected for diallel matings in the greenhouse.

The two 32-chromosome parents were self-incompatible, and their 13 F_1 plants behaved the same way. Among the 13 F_1 plants were four intra-sterile, inter-fertile groups of four, four, three, and two plants, respectively, and all F_1 plants were reciprocally compatible with both parents. With the 178 compatible crosses, the highest seed set per head was 56 and the lowest 23 with an average of 42.2. The differences in average seed set between the plants as females were highly significant in two of the groups (those with four plants each), but not significant in the other two. Among the same plants as males, there were no significant differences in average seed set. With the incompatible crosses, the maximum seed set was 5, the minimum 0, and the average for the 35 heads (three matings were made in duplicate) was only 0.37. This type of self- and cross-incompatibility is explained by assuming that a single series of oppositional alleles conditions pollen-tube growth and that in this case the parents had no alleles in common.

When sectors of the 32-chromosome parent plants were doubled, the oppositional alleles likewise would have been doubled. A cross between two such cuttings should yield the following genotypes in the F_1 generation: (1) Four genotypes, each bearing two different alleles and each in the frequency of one, (2) four genotypes, each bearing three different alleles and each in the frequency of four, and (3) one genotype bearing four different alleles and in the frequency of 16. This frequency is based on random 2 x 2 assortment of the four homologous chromosomes, with no crossing over between the S gene and the centromere. With independent assortment of the eight chromatids, on the other hand, a 9:9:9:9:24:24:24:24:64 ratio would be expected. For the small population used here, it was not possible to distinguish between these two ratios by means of the X^2 test. In a study of this sort, however, the most critical evidence comes from the pattern of incompatible group reactions rather than from the close fit of obtained frequencies of different genotypes to expected ratios.

In order to test this behavior, each of the 29 F_1 plants from the 64 chromosome x 64 chromosome cross was self-pollinated, crossed reciprocally to both parents, and crossed diallely with all of the sister F_1 plants. The results were more complicated than those from the 32 x 32 cross, and they cannot be explained by any of the existing hypotheses. Although the 64-chromosome parents were self-incompatible like their 32-chromosome counterparts, the F_1 generation segregated into three self-incompatible plants and 26 self-compatibles. Three methods of selfing were

used in classifying the plants, and the results from the three methods agreed. As an explanation of these results, it is proposed that plants bearing two different alleles (diallelic) are self-incompatible, whereas plants bearing three or four different alleles (triallelic or tetraallelic) are self-compatible. The former plants would produce only one type of heterozygous pollen, which it is supposed would be inhibited if one or both of the same alleles were present in the style, but the latter would produce three and six types, respectively, and none of these would be inhibited. This proposal is complex, but it is also useful in this form to explain most of the cross-incompatibilities. The obtained ratio of 3:26 does not deviate significantly from expected on the basis of either chromosome or chromatid assortment.

When the self-compatible plants were used as males, all crosses were compatible, but when the self-incompatible parents and F_1 plants were used as male, a number of incompatibilities were obtained. On the basis of these group reactions, the self incompatible plants could be separated into two genotypes and the self-compatible into four. The segregation of 1:2:4:4:3:15 gives a very satisfactory fit to expected based on either chromosome or chromatid segregation. In general, the pattern of incompatibilities which was obtained matched the theoretical very closely, but there were certain discrepancies for which there is no suitable explanation at present. It should also be pointed out that there were highly significant differences in average seed set between certain comparable compatible crosses.

Two additional lines of evidence have been obtained which support the hypothesis of some pollen interaction rather than always specific oppositional effect. In the first place, significant differences due not only to different male groups but also to different male plants within groups were obtained when the results were analyzed in several different ways. Secondly, significant end-season increases in seed set were obtained in at least two types of crosses. Nothing comparable to these two effects has ever been obtained with 32-chromosome plants. They are explained tentatively by assuming that modifying factors would have a better chance for expression in tetraploid plants.

A preliminary paper summarizing these results has been submitted for publication (Page 70).

Varietal Improvement of *Trifolium repens*

Inbreeding Studies. Plantings were made in the 1943 nursery as follows:

90 third generation inbred lines of white clover.
22 second generation inbred lines of white clover.
5 second generation inbred lines of Ladino clover.
13 second generation inbred lines of strawberry clover.

Each line consisted of 30 plants distributed in three randomized blocks. In most cases clones of the original parents were planted with the inbreds. Partly because of the drought in late summer, these plants grew very poorly, and observations on their relative vigor were not very reliable. Nevertheless a few individuals were selected and brought into the greenhouse for a continuation of the combining ability test.

Over the winter of 1942-43 there was experienced in our nursery, as was general throughout the northeastern states, the most severe winterkilling that has occurred since the Laboratory started. At first, it appeared that many of the inbred lines had been completely killed, but as the spring advanced most of them began to grow slowly, often from only one or two stolon ends that had remained alive. Using a score of 0 for the most extreme killing and 10 for the least, notes were taken on every individual in each of the 187 lines. Highly significant differences between lines were obtained in five of the six groups (Table 8).

Table 8. Analysis of winterkilling with inbred white clover.

Experiment No.	Generation inbred	Range in average killing for lines	Variance due to Replication	Lines	Error
1	3	0.13 - 2.22	4.42**	0.85	0.64
2	3	0 - 2.17	0.21	0.88**	0.39
3	3	0 - 2.83	0.62*	0.97**	0.14
4	2	0.17 - 5.10	19.02**	6.90**	0.36
5	2	0.13 - 5.33	15.40**	7.63**	0.74
6	2	0.37 - 3.00	8.19**	1.90**	0.63

* F exceeds value for P = .05
** F exceeds value for P = .01

Much better survival was obtained with the second generation lines than with the third, but this may have been due partly to the more rigorous selection of parents in the case of the former.

Over 6,000 heads were bagged on these winterkilled lines to obtain selfed seed last summer. Since it was possible to bag only the plants which had survived best, there may have been a very beneficial selection in regard to the killing.

Also bagged last summer were approximately 600 F_1 plants obtained from crosses between the S_fS_f plants and some of the individuals selected for tests in sod plots (1942 Annual Report, Page 35). The more vigorous and disease resistant plants were noted as possible parents of new inbred lines. At the same time open-pollinated seed was harvested on the better plants so that a top-cross test may be made either before or simultaneous with the raising of the first inbred generation.

About 75 selected plants of Ladino clover have been brought into the greenhouse for crossing with S_fS_f plants, and the F_1 hybrids will be grown for selection and the production of new inbred lines.

New Sod Plots. Plots were started in 1943 from the 25 plants that were selected as the best among the 1941 series in regard to the ability to grow with grass (1942 Annual Report, Page 35). The weeds were clipped periodically throughout the summer, and the first complete observations on their persistence and yield will probably be taken next summer.

New plots were also established from 242 plants of Ladino clover selected in the 1941 nursery (1942 Annual Report, Page 36) as the most vigorous and disease-resistant individuals. From the vegetative increases in the greenhouse, 36 cuttings of each plant were rooted for the four replications in the field. As a corollary study on method of establishment, 25 of the plants were increased so that single pots of each were transplanted to the middle of 5 x 5 feet plots, half of which had fall-sown grass and half spring-sown. Weeds were clipped on all of these plots, but little growth was made by either grass or clover because of the drought.

Combining Ability of Sod Plot Selections. As a continuation of the previous observations made with this material (1942 Annual Report, Page 35), further crosses were completed in the greenhouse last winter, and plots were established using 44 combinations among the good, medium, and poor selections. Because of some delay in getting the seeds germinated, these plots were set in the field later than the others, and there was somewhat less trouble with weeds.

Combining Ability of Parents and Inbreds. Six selected second generation inbreds and their respective parents were crossed to obtain seed of corresponding inbred x inbred and parent x parent combinations. From nine pairs of matings enough seed was secured to plant eight replications in the field, each replication consisting of a row of nine spaced plants. Also planted in either the third or the eighth position in each row was a cutting of a single vigorous parent to be used for comparison in taking notes. Because of a drought period in the spring, the transplanting of this material was considerably delayed, but good establishment was obtained, and it is planned to note all of these plants for relative vigor next summer.

Ladino Clover Nursery. All seed heads collected last year (1942 Annual Report, Page 36) were threshed separately, and a sample of the seed from each head was used to establish a row of five plants in the field. In this way over 3,000 seedlings were obtained from the 29 pastures where the seed had been gathered. Also transplanted to the field were the 405 cuttings which had been gathered in 17 of these fields at the same time that the

seed was collected. All of this material grew exceptionally well during its first summer, and almost all plants showed the complex of gigas characters usually associated with Ladino. There were conspicuous differences, however, in both vigor and disease resistance, and it is planned to select rigorously within this nursery for new breeding stocks.

Crossing of Selected Plants under Bee Cages. Eight plants of white clover were selected because they had yielded well in sod plots (1940 Annual Report, Page 27) and had exhibited good combining ability as tested by their progeny grown both as spaced plants (1940 Annual Report, Page 26) and in sod (1942 Annual Report, Page 35). These plants were increased vegetatively in 1942 and allowed to intercross under bee cages in 1943. Due to severe killing during the winter of 1942-43, the flowering on these plants was very sparse, and only 21.9 grams of seed was obtained under the eight cages, each of which enclosed cuttings from all eight plants in random order.

In the same way, eight plants of Ladino clover, which had been selected on the basis of their ability to persist and yield with orchard grass, were intercrossed under four cages. These plants killed more severely than the white clover, and only 2.04 grams of seed were obtained.

It is planned to use this seed next year for further progeny tests and increase.

Genetical Studies in *Trifolium repens*

Marker Genes. Last winter crosses were made in the greenhouse to obtain progeny for a study of the inheritance of the following characters:

1. Linkage of red midrib and white V-marking.
2. Chlorophyll deficiency in mature plant.
3. Two dwarf types with abnormal leaves, etc.

The seedlings for the first study are now being classified in the greenhouse, and plants from the latter two are being grown to maturity in the field.

Inheritance of a Cyanogenetic Glucoside and Its Enzyme. When certain F_2 and backcross families involving four separate F_1 plants differed significantly from expected according to the X^2 test (1942 Annual Report, Page 37), additional progenies were grown to determine the cause of the aberrancies. With each of the families and with the total population (375), the obtained segregations did not differ significantly from expected, so that all these data support the hypothesis of single unlinked genes determining respectively the presence of glucoside and enzyme.

On the other hand, the results were more complicated when the same four retested plants were crossed with two individuals which had tested 0-0-0 and, therefore, were presumed to be recessive for both the enzyme and glucoside factors. With these crosses, significant deviations were found among some of the 24 families and total population of 604 in regard to enzyme segregation, glucoside segregation, and linkage. Although most of the results with the two additional tester plants confirm the original hypothesis, there was also obtained some evidence for linkage and for modifying genes.

The results of these studies were incorporated into the paper which had been submitted for publication (Page 70).

Genetics of Rust Resistance. When a natural epiphytotic developed in September on most of the planting used for this study (1942 Annual Report, Page 37), the more vigorous families were classified for degree of infection. Each family had been derived by backcrossing selected F_2 plants to their susceptible and resistant grandparents. A few families, which had come from resistant x resistant crosses, were found to be uniformly resistant. Some others from the susceptible x susceptible crosses were observed to be uniformly and severely infected. Selections were made in each of these types of families, and the chosen plants have been brought into the greenhouse for further matings. It is planned to check further the apparent homozygosity of the selected plants and also to obtain preliminary hybrids between resistant and susceptible plants.

Genetics of Virus Resistance. In 1940 a first generation inbred plant was observed to have severe mottling or mosaic in its leaves, very similar to the injury caused by virus. In this case, however, the plant appeared to be relatively tolerant to the injury and to grow vigorously despite the abundance of symptoms, whereas most virus-infected plants of clover are severely stunted. During the winter 1941-42 this plant was crossed with an apparently virus-free individual, and the F_1 progeny which was planted in the field the following summer segregated very clearly into 33 plants, in which no symptoms were observed, and 12, which showed severe injury like their diseased parent. During their second summer the effect of the injury became even more apparent so that the diseased plants could be distinguished easily from the healthy on the basis of vigor alone. In the winter 1942-43, thirteen selected F_1 plants were intercrossed and backcrossed to both parents. The resultant progenies were grown in the greenhouse last summer and classified for presence or absence of injury at the age of two months. The segregation with these plants was very easy to classify since there were no cases of slight or intermediate injury. Among the 2223 plants which were classified, several types of segregations were obtained (Table 9).

These results are interpretable by assuming that two factors control the disease, that both of them must be present for the diseased condition, and that the diseased parent was heterozygous for both factors.

Table 9. Types of segregation in F_2 and B progenies of virus study.

Generation	Origin of progeny	Segregations obtained
F_2	Diseased x diseased	9:7
"	Diseased x healthy	3:5 or 1:3
"	Healthy x healthy	1:3 or no seg.
B	Diseased P x diseased F_1	9:7
"	Diseased P x healthy F_1	3:5 or 1:3
"	Healthy P x diseased F_1	1:3
"	Healthy P x healthy F_1	No seg.

In every segregating family, the healthy plants appeared much more vigorous than the diseased. This extra vigor was expressed by a larger size of all parts, larger number of parts such as leaves and stolons, and fewer deformities. To obtain a measure of this, the number of completely opened trifoliolate leaves were counted when the plants were six weeks old. For the entire segregating population of 1880, the healthy plants averaged 8.2 leaves and the diseased 4.8. These differences were highly significant in every type of segregating family. (Photograph opposite Page 40.)

Cytological Studies

The only extensive chromosome counts made this past year were with the 32- and 64-chromosome progenies studied for behavior of their oppositional alleles (this report, Page 33). In every case, the progeny had the same number as their parents, no abnormal or aneuploid types being found.

LEGENDS FOR ILLUSTRATIONS
(Opposite page)

Top Photograph.

The deleterious effect of partial soil sterilization and its correction by phosphate fertilization. Growth of Ladino clover with soil treatments as follows:

1. No treatment.
2. Heated at 50° C. for 5 days.
3. Steam sterilized 2 hours at 5 pounds pressure.
4. P_2O_5 at 3,000 pounds per acre.
5. P_2O_5 at 3,000 pounds per acre; heated at 50° C. for 5 days.
6. P_2O_5 at 3,000 pounds per acre; steam sterilized 2 hours at 5 pounds pressure.

(See paragraph on effect of phosphorus on soil sterilization, Page 55.)

Middle Photograph.

On the left is shown a normal leaf of Ladino clover and on the right is a leaf with early symptoms of mottling or mosaic that may eventually kill the plant. Injury of this sort is usually produced by virus, although the agent in this case has not been absolutely identified. There are many types of injury caused by virus, but they all are among the most devastating of the white clover diseases.

With the disease shown here, a genetic study has demonstrated that susceptibility is conditioned by two dominant factors. Selection for resistance in a breeding program could be accomplished relatively easily (see paragraph on "Genetics of Virus Resistance", Page 38).

Bottom Photograph.

A population of Ladino clover during the second summer in the field showing segregation for resistance to virus-like injury. All small weakened plants have had the disease, whereas the larger plants have been healthy. The presence of the disease during the first year in the field so weakened the diseased plants that some were killed during the winter and all were severely restricted in vegetative growth during the following summer, as shown here.


1
2
3
4
5
6

PHYSIOLOGY AND COMPOSITION OF PASTURE PLANTS

Extraction of a Protein Concentrate from Grass

Because of the shortage of protein concentrates for animals, experiments were undertaken on the preparation of a protein concentrate from grass. By extraction of grass with sodium hydroxide a solution was obtained which on neutralization and slight acidification yielded a precipitate containing more than twice the concentration of protein contained in the original grass and with only minor amounts of fibrous constituents. The use of such a concentrate as a poultry feed is being investigated.

The yield of this concentrate and its percentage of protein was influenced by the protein content of the grass, by the concentration of the alkali used for extraction and by the temperature during extraction. Young grass gave abundant protein precipitates containing 50 per cent or more of protein and accounting for more than 40 per cent of the total protein of the grass. Mature summer hay gave low yields of precipitates containing low concentrations of protein. Some of the preparations are described in Table 10. In all cases an overnight extraction at room temperature was carried out.

Table 10. Data on protein concentrates from grasses, prepared by extraction overnight with alkali at room temperature.

Description of grass used	Crude protein in grass (per cent)	Concentration of alkali (normality)	Protein in prepared concentrate (per cent)	Recovery of protein N from grass (per cent)
Mixed grass, early spring	22.6	0.25	54.1	40.7
Mixed grass, fall	23.1	1.00	57.0	48.7
Kentucky bluegrass and white clover, early spring	21.0	0.18	47.8	41.1
	-	2.00	33.1	14.7
Kentucky bluegrass and white clover, early spring	-	1.00	48.3	49.3
	-	0.50	50.6	52.2
	-	0.25	51.9	43.2
	-	0.10	58.8	23.6
Grass hay, summer	10.5	0.50	24.2	low
Red clover hay, summer	13.1	0.25	30.7	low
Timothy hay, summer	7.1	0.25	16.8	low

The protein concentrate is dark green in color and when first prepared contains a considerable amount of carotene, which decreases in storage. It has a grassy flavor, not palatable to the human taste. By extraction with alcohol the flavor is removed, as well as considerable amounts of non-protein constituents, thus increasing the protein percentage. A product containing 72 per cent protein was obtained by this method.

Considerable mechanical difficulty has been encountered in washing, filtering and drying the precipitate. Studies are being made leading to the simplification of the procedure. A quantity of the concentrate is being prepared for feeding trials with poultry.

Papers presenting preliminary results of these studies have been prepared for publication (Page 70).

Photoperiodic Responses of Several Pasture Species

In previous studies (1942 Annual Report, Pages 42 and 43), it was shown that the length of the dark period rather than the length of the light period appeared to be the factor controlling the flowering of the orchard grass grown under long photoperiods. During the past year four clones of orchard grass, one clone each of Canada bluegrass, Kentucky bluegrass, and a Canada-Kentucky bluegrass hybrid and six clones of white clover, were supplied with supplementary light at various times during the night to determine their responses to short dark periods. After several months' growth under a normal winter day length (9-10 hours), four replicate pots of each clone of each species were transferred to the following light conditions:

10-hour day and 14-hour night.
12-hour day and 12-hour night.
16-hour day and 8-hour night.
10-hour day and two 6-1/2 hour nights (light 12:30 to 1:30 a.m.)
10-hour day and two 6-hour nights (light 12:00 midnight to 2:00 a.m.)
10-hour day and three 4-hour nights (light 10:00 to 11:00 p.m. and 3:00 to 4:00 a.m.)

Six weeks after the plants were placed under the above light treatments the number of heads were counted (Table 11). No heads were produced by any of the grasses grown under a 10-hour photoperiod and but few were produced under the 12-hour photoperiod. When a 16-hour day was provided, the heading of each clone was similar to its heading behavior in the field. Where the normal dark period of 14 hours was broken either by one hour or two hours of supplementary light in the middle of the dark period or by two 1-hour

light periods so arranged as to divide the normal dark period into three 4-hour dark periods, the number of heads produced was similar to that produced under a 16-hour light period and an 8-hour dark period.

Clonal response to daylength appears to be less definite in white clover than in the orchard grass or Canada bluegrass (Table 11). However, the number of heads produced under theseveral light treatments indicate that the length of dark period is an important factor in head formation and that there is probably little difference between the effect of a 16-hour day and any of the treatments where supplementary light is supplied for one or two hours during the dark period.

In this experiment the clone of Kentucky bluegrass or the Canada-Kentucky bluegrass hybrid used did not head under any of the light treatments employed.

Table 11. Number of heads produced by orchard grass, Canada bluegrass and white clover under various photoperiods. Each figure is the average of four replicates.

Species and clones	16-hr. day 8-hr. night	12-hr. day 12-hr. night	10-hr. day 14-hr. night	10-hr. day Two 6-1/2 hr. nights	10-hr. day Two 6-hr. nights	10-hr. day Three 4-hr. nights
Orchard grass						
48(280)	3.7	1.7	0	3.5	4.5	3.2
20(16)	5.0	1.7	0	5.2	4.2	4.7
12(7)	2.7	0.7	0	0.7	1.7	2.0
11(11)	0	0	0	0	0	0.2
Average	2.8	1.1	0	2.4	2.6	2.8
Canada bluegrass						
138(531)	15.0	0.7	0	26.0	12.5	18.2
White clover						
72(172)	16.2	1.0	0	12.2	13.7	17.5
40(34)	9.5	1.2	3.7	4.2	6.2	8.2
15(31)	18.5	10.5	12.2	17.5	16.5	18.2
24(3)	13.7	8.5	7.5	13.7	18.5	19.5
58(21)	4.5	2.5	1.7	4.0	3.5	8.5
62(111)	10.0	10.2	9.2	8.7	9.0	6.5
Average	12.1	6.0	5.7	10.1	11.2	13.1

At the time the heads on the grasses were counted, it was apparent that there were also considerable differences in the vegetative growth made by the several grass species and that these differences appeared to be somewhat independent of the flowering responses. The top growth of each pot was removed and its dry weight determined. It is obvious from these dry weights (Table 12) that increasing the daylength increased the top growth of all clones of all species used. Further it appears that breaking the normal dark period of 14 hours with one or two hours of supplementary light increased dry matter production to a point approaching that obtained under a 16-hour photoperiod. That this may be definitely a photoperiodic response and not due alone to additional radiant energy available for photosynthesis is strongly suggested by the fact that the average yield of all species supplied only one hour of light at an intensity of 60-75 foot candles in the middle of the dark period increased the yield 1.12 grams per pot over those plants receiving the same normal daylength but no supplementary light. This increase is approximately 30 per cent and would appear too high to be due alone to increased energy for photosynthesis when the supplemental light supplied was of such low intensity and for such short duration.

Table 12. Dry weight of tops produced by orchard grass, Canada bluegrass, Kentucky bluegrass, and a Canada-Kentucky bluegrass hybrid grown under various photoperiods. Each figure is the average of four replicates.

Species and clones	16-hr. day: 8 hr. night	12-hr. day: 12 hr. night	10-hr. day: 14-hr. night	10-hr. day: Two 6-1/2 hr. nights	10-hr. day: Two 6-hr. nights	10-hr. day: Three 4-hr. nights
	grams	grams	grams	grams	grams	grams
Orchard grass						
48(280)	6.78	4.23	3.81	5.79	6.65	6.08
20(16)	5.20	3.75	2.75	5.57	4.66	6.06
12(7)	9.86	6.34	5.44	7.98	6.69	7.16
11(11)	7.01	4.98	4.65	5.41	5.72	8.63
Average	7.21	4.82	4.16	6.19	5.93	6.98
Canada bluegrass						
138(531)	4.88	3.46	2.70	4.46	5.19	5.18
Kentucky bluegrass						
96(1)	3.69	3.11	2.49	2.94	2.69	2.68
Canada-Kentucky bluegrass hybrid	2.78	2.36	2.07	2.69	2.77	2.47
Average of all species	4.64	3.44	2.85	4.07	4.14	4.33

Vegetative Responses of Several Grasses and Legumes to Supplementary Light

Greenhouse trials were conducted with 14 plant species to determine the effects on vegetative growth of the length of light period, the length of the dark period, and of increasing the intensity of the natural light on dark days. The yields of top growth and root growth and the general habit of growth were determined.

The experiment was conducted during the winter months when the natural daylength varied between 9 and 10 hours. Daylengths of 11, 13, 15 and 17 hours were obtained by increasing the length of the natural light period with light provided by Mazda lamps at an intensity of approximately 75 foot candles. The effect of the length of the dark period was studied with one series of plants, which received the natural daylength (9-10 hours) but the normal dark period (14-15 hours) was interrupted with two hours of artificial light, thus providing two 6-hour dark periods.

Inasmuch as the light intensity during the winter months is usually low, it was thought advisable to determine whether supplementing the natural light on dark days would increase growth. A photoelectric relay was devised whereby Mazda lights were turned on automatically during periods of low light intensity. The Mazda lights provided artificial illumination of about 250 foot candles which supplemented the natural light. The number of hours of supplementary light provided during the growth period ranged from 0 to 8 hours per day with an average of 2.0 hours.

The different crops were seeded in four replications in 1-gallon pots of soil on October 26. During the period December 27 to January 5 the soil was washed from the pots and the yield of roots and tops determined. Since all plants could not be harvested on the same day the higher yielding species were washed out first. Thus barley and tomato were harvested on December 27 and birdsfoot trefoil and Kentucky bluegrass on January 5.

The yields of the above-ground parts are summarized in Table 13. In general, very little response was obtained by increasing the light intensity during the day. The effects obtained by varying the daylength and the length of the dark period depended upon the plant species. A slight increase in length of day produced a marked increase in yield of timothy. In orchardgrass the response to two hours of light at midnight was similar to that obtained under a 15-hour day. Birdsfoot trefoil, red clover, and Ladino clover produced the most dry matter under a 17-hour day, although in Ladino clover the difference between the 15- and 17-hour days was very small. Sweet clover on the other hand grew almost equally well under daylengths of 11, 13, 15, and 17 hours. Perennial ryegrass and bromegrass showed very little if any yield response to light treatments, and in alfalfa and redtop the response was relatively small. Kentucky bluegrass was poorer when grown under the 17-hour day than under a normal day.

Table 13. Vegetative response of different plant species to daylength in the greenhouse.

Plant species	Yield of tops, grams per 4 pots						
	Natural day 9-10 hrs.	9-10 hr. day but increased intensity	Natural day plus 2 hrs. at midnight	11 hr. day	13 hr. day	15 hr. day	17 hr. day
Timothy (Milton)	7.5	10.1	12.0	11.7	12.3	14.4	13.1
Orchard grass	12.7	13.2	19.6	14.9	18.9	20.0	17.4
Birdsfoot trefoil (Broad leaf)	3.7	4.9	5.5	4.4	6.6	8.6	10.6
Red clover (Dollard)	10.5	9.8	12.2	11.6	13.0	12.6	15.1
Ladino clover	8.4	8.0	10.7	8.8	7.8	11.6	11.9
Sweet clover (Evergreen)	11.1	11.9	13.0	14.2	13.8	14.3	15.3
Alfalfa (Grimm)	12.4	12.9	13.7	13.0	12.7	14.7	13.8
Redtop	11.5	10.6	12.2	12.6	13.5	13.8	13.0
Tomato (Ponderoso)	23.7	26.3	25.8	21.3	24.7	25.9	27.6
Barley (Wisconsin No. 38)	34.3	33.0	43.0	39.1	44.4	46.7	38.8
Kentucky bluegrass	9.4	10.5	9.9	10.7	9.6	11.1	6.0
Perennial ryegrass	20.3	18.4	21.5	19.0	18.8	20.0	19.8
Sudan grass	14.8	17.9	14.8	15.1	13.9	16.0	15.4
Bromegrass (Nebraska grown)	15.3	16.2	13.8	14.7	15.6	16.5	14.4

In all cases the longer days resulted in greater leaf and stem elongation even by the species that produced no increase in total yield of dry matter. In general, plants grown under the natural daylength (9-10 hours) and supplied with two hours of light in the middle of the normal dark period responded similarly to those grown under a 13-hour photoperiod.

Differential Responses to Clipping and Chromosomal Reduplication in *Lolium perenne*

Data previously reported (1940 Annual Report, Pages 33-35) indicated that reduplication of chromosomes in itself does not necessarily increase the total growth capacity of a plant but that there is a differential response to chromosome doubling depending upon the gene base reduplicated and the clipping treatment employed.

During the winter of 1943, a similar experiment was conducted using seven new 2n clones paired with their respective 4n clones and one 2n-4n pair used in the former trials. As in the earlier study, the 4n clones were obtained by treating germinating seedlings with colchicine (1938 Annual Report, Page 33) and repeatedly increasing them by vegetative means until pure 2n and 4n clones were obtained (1942 Annual Report, Pages 28 and 29). In this experiment, one complete series was grown in soil and a second in gravel, clippings being made at intervals of three weeks and six weeks in each series. Eight pairs of diploid and tetraploid clones from eight single seedlings were used in each series. The gallon glazed pots in which the plants were grown were arranged in a split plot design where the soil and gravel constituted the main plots and the two clipping treatments the first sub-plots, the eight clones the second sub-plots and the chromosome numbers the third sub-plots. The plants were grown during the winter months when the natural light intensity was low, averaging from about 4500 to 5500 foot candles. The daylength was increased to 14 hours by means of Mazda lamps providing an intensity of approximately 75 foot-candles at the soil or gravel surface. Five single tillers of a clone were established in each pot. The soil used was fertile and the gravel was supplied with a balanced nutrient solution by automatic irrigation (1938 Annual Report, Pages 52 to 54).

Two and one-half months after planting and just before the clipping treatments were started, the total number of tillers in each pot was determined. These data indicated that reduplication of chromosomes decreased the amount of tillering in all clones, but there was an indication that tillering may have been reduced to a greater extent in some clones than in others.

At the same time the tiller counts were made, it was noted that the leaf color of the plants growing in gravel culture varied from a yellow-green to a deep blue-green. A classification of intensity of green color was made on each pot. The results obtained indicated clearly that a marked difference in color existed between clones and that in five out of the eight clones the tetraploid was darker green, in one clone the diploid was darker green and in the other two, it is doubtful whether there was a significant difference.

The yield data, while they have not as yet been critically examined, suggest relationships similar to those previously reported. The responses of the clones in soil and gravel culture differed depending upon the clone used and the clipping treatment employed. In most instances, the dry weight of stubble and roots of the diploid clone was greater than that obtained from the tetraploid obtained from the same seedling. However, the yield of herbage removed on the several clipping dates from the diploid and tetraploid clones was dependent upon the clipping treatment employed and upon the medium in which they were grown. The diploid clone from one seedling outyielded the tetraploid clone under one set of conditions whereas under other conditions there was no difference. Similarly, the tetraploid clone outyielded the corresponding diploid under certain treatments but under other treatments there was no difference.

In general, the response obtained from reduplication of the chromosomes appears to be dependent upon the nature of the gene base reduplicated and upon the conditions under which the plants are grown.

Composition of Diploid and Tetraploid *Lolium perenne* with Respect to Certain Chemical Constituents

Further analyses were made of diploid and tetraploid ryegrass (1942 Annual Report, Page 52).

In six clones grown in field rows, the tetraploids were significantly higher in sucrose and total sugars but not in reducing sugars. There were no significant differences between the diploid and tetraploid plants in the cellulose and lignin contents.

A paper summarizing these results and those of preceding years has been prepared for publication (Page 70).

The Effect of Temperature on the Emergence and Early Seedling Development of Hay and Pasture Plants

Previous results on the effect of environment on the early seedling development of several pasture species (1942 Annual Report, Pages 43 to 45, and Page 45 of this report) indicated a marked response to temperature and daylength. The work was continued using several

additional species. The plants were grown in the environmental control chambers (1941 Annual Report, Pages 2 and 3) at daily alternating air temperatures of 50° to 65° F., 60° to 75° F., 70° to 85° F., and 80° to 95° F. At each air temperature, there was conducted one test with soil temperatures the same as the air temperature and one test with the soil temperature 10 degrees below the air temperature. Artificial light at an intensity of approximately 700 foot candles was provided for 14 hours each day. The species used in these studies included Ladino clover, red clover, alfalfa, bromegrass, meadow fescue, orchard grass, Kentucky bluegrass and Sudan grass. Twenty-five seeds of each species were seeded on fertile soil in 4-inch glazed pots and covered with one-fourth inch of screened soil. About 10 days after emergence, the plants were thinned to ten plants per pot. Four replicates of each species for each environment were used to provide the data obtained.

The per cent emergence of the eight species was not greatly affected by temperature except at air and soil temperatures of 80° to 95° F. At this extreme the emergence of Ladino clover, orchard grass and Kentucky bluegrass was reduced about 50 per cent and alfalfa, red clover and bromegrass from three to ten per cent. The emergence of meadow fescue and Sudan grass was not seriously affected at this temperature. The emergence of Sudan grass progressively decreased as the temperature decreased but whether this can be attributed to temperature alone is questionable since the Sudan grass roots were severely infected with Pythium at the time they were washed from the soil.

Following growth periods of two, four and six weeks after emergence, the pots were removed from the chambers and the roots washed free of soil. Growth responses, including the dry weights of roots and tops, number and height of leaves, and number of tillers, were obtained.

It is apparent (Table 14) that lowering the soil temperatures 10° F. below the daily alternating air temperatures of 80° to 95° F. greatly increased both root and top growth of all species except Sudan grass. The three legumes, Ladino clover, red clover and alfalfa, were definitely favored by higher temperatures (70° to 85° F. air and either 60° to 75° or 70° to 85° F. soil temperatures) than were the grasses. The data further indicate that the range of temperature adaptability may be greater for the grasses than for the legumes. Kentucky bluegrass appeared to have an optimum definitely lower (50° to 65° F. soil temperature and 50° to 65° F. or 60 to 75° F. air temperature) than any other species. Meadow fescue appeared to have a lower optimum than bromegrass or orchard grass. The yield of both tops and roots of Sudan grass increased with increasing soil and air temperatures throughout the entire range used.

Table 14. Dry weight in milligrams per plant* of eight species of grasses and legumes six weeks after emergence when grown under various combinations of air and soil temperature.

Species	Air temperature 50-55° / Soil temperature 40-55°	Air temperature 50-55° / Soil temperature 50-65°	Air temperature 60-75° / Soil temperature 50-65°	Air temperature 60-75° / Soil temperature 60-75°	Air temperature 70-85° / Soil temperature 60-75°	Air temperature 70-85° / Soil temperature 70-85°	Air temperature 80-95° / Soil temperature 70-85°	Air temperature 80-95° / Soil temperature 80-95°
	Tops							
Ladino clover	5.7	9.8	15.9	23.0	56.4	54.7	51.5	11.0
Alfalfa	9.9	19.9	26.0	38.5	89.3	83.3	71.3	26.0
Red clover	12.9	21.1	27.0	42.1	88.4	76.8	64.5	15.8
Bromegrass	34.0	62.5	67.1	97.2	103.0	91.8	88.8	21.7
Meadow fescue	38.7	93.5	91.7	101.1	78.8	83.1	49.6	7.4
Orchard grass	37.4	71.3	82.7	87.2	90.5	77.1	57.9	5.4
Kentucky bluegrass	18.4	42.5	38.1	36.4	29.4	33.2	22.6	2.1
Sudan grass	13.8	28.3	45.6	77.3	227.8	284.5	416.3	467.8
	Roots							
Ladino clover	3.6	4.8	5.5	6.3	11.3	11.6	8.9	3.1
Alfalfa	8.5	10.4	12.0	11.6	29.2	24.8	19.4	5.4
Red clover	8.1	10.2	11.4	13.5	23.6	17.8	13.2	5.7
Bromegrass	23.6	35.1	36.6	49.8	38.7	36.9	28.3	10.7
Meadow fescue	18.1	34.6	33.9	33.9	22.5	24.1	12.1	2.9
Orchard grass	12.3	22.5	24.4	25.2	24.3	20.6	17.0	2.8
Kentucky bluegrass	5.8	13.5	11.2	10.4	6.2	6.1	4.0	0.5
Sudan grass	8.7	22.3	30.9	45.9	116.0	137.5	163.0	173.8

* Each figure is the average of four replicate pots containing 10 plants each.

Table 15. Root-top ratios* of eight species of grasses and legumes six weeks after emergence when grown under various combinations of air and soil temperatures.

Species	Air temperature											
	50-65°		60-75°				70-85°				80-95°	
	Soil temperature		Soil temperature				Soil temperature				Soil temperature	
	40-55°	50-65°	50-65°	60-75°			60-75°	70-85°			70-85°	80-95°
Ladino clover	.63	.49	.35	.28			.20	.22			.17	.28
Alfalfa	.85	.56	.46	.31			.33	.30			.27	.21
Red clover	.62	.49	.43	.32			.27	.23			.20	.37
Bromegrass	.69	.56	.55	.51			.37	.40			.33	.49
Meadow fescue	.46	.37	.38	.34			.29	.29			.26	.40
Orchard grass	.33	.32	.30	.29			.27	.27			.29	.54
Kentucky bluegrass	.33	.32	.29	.29			.21	.19			.18	.25
Sudan grass	.63	.77	.67	.59			.51	.52			.40	.37

* Each figure is the average of four replicate pots containing 10 plants each.

In general, the root-top ratios increased as the temperature decreased (Table 15). At air temperatures of 50° to 65° and 65° to 75°, lowering the soil temperature 10° F. below the air temperature definitely increased the proportion of roots to tops of the three legumes and of bromegrass and meadow fescue. The root-top ratios of orchard grass were nearly the same throughout the entire temperature range. At the highest air and soil temperatures the root-top ratios increased slightly for all species except alfalfa and Sudan grass. These two species, it will be noted from Table 14, were not as severely injured by the high temperatures as were the other species.

The length of roots, height of tops and number of leaves were greatest at the temperatures at which greatest growth was made.

Carbohydrate Metabolism of Grasses

Changes in the composition (largely carbohydrates) of roots and stubble of perennial ryegrass after defoliation have been studied further (1942 Annual Report, Page 51). Studies have been conducted to determine the effect of temperature on the changes in chemical composition of the stubble and roots during the recovery period following a partial defoliation.

Clonal tillers of perennial ryegrass were established during the winter in soil in the greenhouse and allowed to grow for three months under a 16-hour day. After clipping the plants to a uniform height of two inches, the pots were divided into four equal groups, each of which was placed into one of four environmental control chambers. These chambers provided alternating day and night temperatures of 50° to 60° F., 60° to 70° F., 70° to 80° F., and 80° to 90° F. with the lower temperature being maintained constant for four hours during the dark period, the higher temperature being maintained constant for four hours during the light period, and the transition occurring at a constant rate during the 8-hour intervening periods. Light was supplied by "daylight" and "white" fluorescent lamps at an intensity of 500 to 550 foot candles at the soil surface to provide a 14-hour day.

Plants were removed for chemical analysis on the day of clipping and 4, 9, 14, 21, 28, and 40 days thereafter. The yields of dry matter were obtained and chemical analyses made upon the tops, stubble and roots and upon the new leaf growth above the clipping height.

New leaf growth following clipping, expressed as grams of dry matter per pot was greatest at 60° to 70° F. and least at 80° to 90° F. After cutting, the stubble and roots decreased in dry weight at all temperatures but the decrease was most rapid at the higher temperatures.

A portion of the chemical analyses have been completed. Soluble carbohydrates decreased in both stubble and roots after the tops were removed. Sugars reached their lowest level in the stubble under the 70 to 80 degree temperature and in the roots under 80° to 90° F. Fructosans showed a very rapid decrease at the higher temperatures. During a 28-day recovery period, fructosans dropped in the roots from 4.94 per cent at the time of clipping to 2.75 per cent at 50° to 60° F., 2.35 per cent at 60° to 70° F., 2.10 per cent at 70° to 80° F., and 0.42 per cent at 80° to 90° F. Similar changes took place in the stubble. From an original of 27.50 per cent, fructosans dropped to 18.47 per cent at 50° to 60° F., 9.91 per cent at 60° to 70° F., 8.35 per cent at 70° to 80° F., and 5.00 per cent at 80° to 90° F. There was evidence of restorage of fructosans in the stubble by the end of 40 days at the lower temperatures but not at the higher temperatures.

Clonal Variation in the Response of *Poa pratensis* to Nitrogen Fertilization and Management

Twenty selected clones of Kentucky bluegrass were grown in gallon jars in the greenhouse with three nitrogen levels, two clipping treatments and two day lengths, in three replications. Most of the treatments were terminated at the end of four months, at which time the soil was washed from the underground parts and the total weights of roots, rhizomes, and stubble were determined.

Different clones showed large variations in total yields of dry matter as well as in the ratio of tops, stubble, roots, and rhizomes (Table 16). The weight of roots, however, was highly correlated with the weight of tops. Clonal differences in the response to nitrogen fertilization were less marked than differences due to clipping treatments. Clone 175 produced 42.8 grams of dry matter when clipped at intervals of one month and 84.7 grams when clipped at intervals of two months, whereas Clone 120 yielded 61.1 and 85.0 grams, respectively, under these two clipping treatments. These variant responses may have been due in large part to differences in the growth habits of the two clones. The first clone produced elongated leaves with but little green material near the base of the tiller and, therefore, was severely defoliated at every clipping. Clone 120 was much less severely defoliated even when clipped at the same height (1-1/2 inches).

The growth habit of these clones in the greenhouse, particularly under an artificial long day during the winter months, is so different from the growth habit in the field that no conclusions can be drawn regarding field behavior.

Table 16. Clonal differences in the yield of tops, stubble, roots and rhizomes of Kentucky bluegrass when grown under similar conditions in the greenhouse.*

Clone No.	Yield of dry matter, grams per three pots				
	Tops	Stubble	Roots**	Rhizomes	Total
131	33.1	14.2	11.4	2.6	61.3
120	23.7	17.2	9.4	10.8	61.1
135	26.1	14.5	7.8	10.2	58.6
181	26.3	15.2	8.4	4.7	54.6
152	23.1	17.3	7.8	4.4	52.6
140	27.4	16.3	6.1	0.1	49.9
175	23.0	8.2	5.9	5.7	42.8
142	17.5	7.3	4.4	0.9	30.1
28	16.9	7.5	2.7	2.4	29.5

* High nitrogen fertilization, 17 hour daylength, and clipped four times at intervals of one month.

** Loss on ignition.

Soil Moisture in Relation to Pasture Management

In the fall of 1942, gypsum blocks were installed under a Kentucky bluegrass sod at depths of 4, 10, and 20 inches. The following treatments were applied to quadruplicate plots:

1. No nitrogen; clipped to 1-1/2" when 5 to 6".
2. High nitrogen; clipped to 1-1/2" when 5 to 6".
3. High nitrogen; clipped as hay and aftermath.

Soil moisture readings were taken at irregular intervals during the early part of the season and at intervals of two days during the latter part of the season. Although moisture was adequate in the spring, the latter part of the season was very dry; the data obtained indicated that the soil moisture content was below the wilting coefficient to a depth of more than 20 inches most of the time.

Nitrogen fertilization gave marked increases in yield of herbage but the increased yield from nitrogen and a deferred clipping treatment had very little effect on the soil moisture content. Somewhat contrary to what might be expected, the nitrogen treated plots at certain times during the season were higher in moisture content than those receiving no nitrogen. This appeared to be due to an increased rate of infiltration of moisture as a result of nitrogen fertilization. This may be an important factor during rains of high intensity.

Clonal Variation in the Mineral Content of *Trifolium repens*

In previous work (1942 Annual Report, Pages 52 and 53) it was found that clones of white clover that were high in percentage calcium, phosphorus, or potassium when grown on one soil were also high in calcium, phosphorus, or potassium on other soils, provided climatic conditions were the same. Changes in climatic conditions resulted in changes in mineral content but different clones responded differently. Thus a clone might be relatively high in calcium at one time but relatively low at another time. This year, in a preliminary trial to determine the importance of environmental factors, two selected clones were grown in control chambers at four different temperatures. Yields of dry matter were determined and analyses will be made for calcium, phosphorus, and potassium.

Improvement in the Method of Determining Hydrocyanic Acid

A method described previously for the determination of hydrocyanic acid in white clover (1939 Annual Report, Page 41) involved the assumption that HCN was liberated from its parent glucoside by the hydrolyzing enzyme present in the plant. Since then it has been shown elsewhere that the hydrolyzing enzyme may be absent although the glucoside may be present. This has been confirmed by work at the Laboratory (1942 Annual Report, Page 37). It was necessary, therefore, to modify the quantitative method of analysis by adding to the plant sample sufficient prepared enzyme to hydrolyze the glucoside. The conditions necessary for carrying out the procedure have been studied and a paper summarizing the results has been prepared for publication (Page 70).

Plant Growth on Partially Sterilized Soil

The results previously reported (1942 Annual Report, Pages 54 and 55) showed that liberal applications of phosphate effectively corrected the poor plant growth that sometimes follows partial soil sterilization. Apparently, however, the injury is due to the presence of some toxic substance rather than to a deficiency of available phosphate. The results obtained in these studies have been submitted for publication (Page 70; photograph opposite Page 40). Studies are being continued to determine the nature of the inhibiting substance.

PATHOLOGY

Studies in Ustilago striaeformis

Prevalence and Distribution of Stripe Smut of Poa pratensis in Some Pastures of Pennsylvania. The examination of plugs collected from representative bluegrass pastures (1942 Annual Report, Page 57) for prevalence and distribution of smut was completed and a manuscript was submitted for publication (Page 70). The results showed that prevalence of stripe smut of P. pratensis may be much greater than superficial examination would ordinarily disclose. The high percentage of smutted plugs collected from some pastures leaves little doubt that stripe smut may be important in reducing yields. The observed decrease in prevalence of smut during hot summer months is probably due to death, at least of the aboveground parts, of many diseased plants. This may account, to some extent, for the so-called "drying-up" of some bluegrass pastures during the summer season.

As shown in Table 17, stripe smut caused by U. striaeformis was present at the time of sampling to the extent of 0.5 to 11.4 per cent of the sod plugs collected. The total number of plugs recorded as containing smutted plants during a 5-month observation period varied for different pastures from 4.5 to 34.4 per cent.

Table 17. Per cent of plugs with smut-infected plants at different periods of examination and total per cent smut.

Pasture No.	Months after collection					Totals*
	0	1	2	3	5	
70	7.6	12.0	18.1	19.5	17.7	30.0
71	4.9	9.3	14.2	13.0	11.7	25.9
72	4.0	4.0	5.0	6.5	5.5	10.0
73	0.5	1.5	2.1	2.0	1.5	4.5
74	5.5	6.0	9.0	11.0	10.0	16.5
75	11.4	15.3	18.1	18.7	14.9	31.0
76	3.9	9.9	20.8	25.3	25.2	34.4
77	5.5	8.4	13.4	9.9	14.9	21.8
78	11.1	10.5	13.5	17.0	13.0	23.0
79	10.6	12.6	15.2	14.2	12.7	23.9
80	9.0	16.3	18.2	17.2	19.1	29.5
81	3.9	7.7	7.7	7.8	8.3	14.6
82	2.0	5.0	5.0	4.5	4.6	11.0

* Total per cent smutted plugs recorded during the entire observation period.

The distribution of stripe smut in pastures sampled was variable. Some pastures contained a fairly uniform infection over the entire area sampled, while others contained different amounts for different areas. There was no consistent relationship between topography and distribution of smut.

Differential Afterripening of Smut Chlamydospores. Investigations were continued to determine the factors responsible for afterripening chlamydospores of U. striaeformis. It was discovered that smut chlamydospores in leaves of Poa pratensis and Agrostis alba were easily afterripened by incubating detached smutted leaves at 35° C. in a moist chamber for 10 to 20 days. Smut spores in leaves of Dactylis glomerata and Phleum pratense failed to respond as readily to the treatment. This may indicate differences in the races of smut or differences in the chemical composition of the respective hosts which may in turn influence afterripening of the spores.

The problem is being further studied by incubating smutted clones of the different species at different temperatures as described previously (1942 Annual Report, Page 56).

Influence of Storage Temperature and Moisture on Viability of Afterripened Chlamydospores. Chlamydospores from P. pratensis and A. alba were afterripened by the technic described in a recent publication (Page 70). The afterripened chlamydospores were separated from the host tissue by macerating them in distilled water in a Waring blendor. The spore suspension so obtained was filtered through a single thickness of cheesecloth to remove coarser particles of plant material. The spore suspension was then subjected to three cycles of alternate washing with sterile water and slow-speed centrifugation in an angle centrifuge to remove as much of the remaining plant material and contaminating organisms as possible. After the final washing, the spore sediments were resuspended in a few cc. of sterile water and combined. The concentrated spore suspension was then recovered on a fine grade of filter paper. The paper containing the spore suspension was cut into small pieces and then dried overnight at 35° C. Approximately equal numbers of filter paper bits containing spores were placed in Petri dishes for storage at each of the following temperatures: Freezing, 5° C., 15° C., 25° C., and 35° C. Preliminary results from this experiment indicate that afterripened chlamydospores retain their viability best at freezing and 5° C. Spores stored dry at low temperatures remained viable longer than those stored wet.

Physiology of Afterripening in Chlamydospores of U. striaeformis. Since high temperature and a moist atmosphere seemed necessary for successful afterripening of smut chlamydospores from P. pratensis and A. alba, it was considered possible that contaminating organisms on the surface of smutted leaves might influence, in some manner, the breakdown of host tissue, thus hastening the afterripening of the chlamydospores. To test this possibility, freshly gathered smutted

leaves of P. pratensis and A. alba were surface sterilized in 1:1000 Hg Cl_2 for a short time and then rinsed in several changes of sterile water. The surface-sterilized tissues were transferred to sterile Petri-dish moist chambers and incubated at 35° C. Germinable spores were secured five to 30 days after the incubation treatment was started but afterripened spores seldom exceeded 50 per cent germination. In some tests, few spores germinated suggesting that possibly surface sterilization had proved toxic to the spores.

In another experiment, spores were separated from fresh, green smutted leaves of P. pratensis and collected on filter paper as described above. The filter paper bits were stored in moist chambers at temperatures of 5°, 25°, and 35° C. Fresh spores treated in this manner germinated up to 50 per cent after 12 to 19 days' treatment at 35° C., indicating that host tissue probably was not necessary for afterripening smut chlamydospores from P. pratensis and that temperature and moisture are very likely the main factors that determine the rapidity with which chlamydospores of U. striaeformis are afterripened.

Development of Latent Smut Infections in Plants of P. pratensis. From previous observations made at the Laboratory, it seemed possible that latent infections of smut may occur in some of the grasses. Some observations on this problem have been carried on since 1941. At present, single healthy and smutted tillers from two different clones of Kentucky bluegrass are being propagated and observed for development of smutted shoots.

Seed Transmission of U. striaeformis. During the fall of 1942 smutted plants of P. pratensis, D. glomerata, A. alba, and P. pratense were transplanted to a field with the expectation that sufficient seed would be formed the following summer to test the possibility of seed transmission of smut. The severe winter of 1942-43 killed all the smutted plants of D. glomerata, but many of the plants of other species survived. Seed was produced, however, only on smutted plants of timothy. Approximately 1,000 seeds were obtained. One-half of the seeds were treated in 1:500 Hg Cl_2 to kill smut spores that might be clinging to the surface of the seeds; the other group of seeds was left untreated. Both sets of seeds were then sown in flats of steamed soil and kept in a greenhouse. Observations to date indicate that surface sterilized seeds produced healthy seedlings while a few of the seedlings from the unsterilized seeds yielded smutted plants. The data to date, however, are still too limited to warrant drawing definite conclusions.

Studies on Damping-off of Forage Grasses and Legumes

Field Tests. During the spring of 1943, field tests with treated seeds of alfalfa and red clover were arranged in cooperation with the Plant Pathology Extension Service of The Pennsylvania State College. A total of 29 tests with alfalfa and 31 tests with red clover were established in 18 counties in Pennsylvania. The seeds for all tests were treated and packaged at the Laboratory. Each dust was applied in excess to the amount the seed would retain and the excess was then screened off. Tests designated as "College" or "Centre County" were cared for by the Laboratory while all others were cared for by County Agents, growers, and Plant Pathology Extension specialists. Each demonstration consisted of triplicated plots arranged at random with 200 seeds planted in each plot. Laboratory germination tests showed that the alfalfa and red clover seed used germinated more than 80 per cent. The tests were planted from March 22 to June 25. Counts of seedling stands were made when the seedlings were one to four inches high. The results of the tests are summarized in Table 18. In order to reduce the voluminous data, the results of many tests were combined for plantings made during March and April. Similar treatment was accorded plantings made during May and June.

Work to date indicates that certain seed treatments may prove valuable for improving stands of forage legumes but further field tests are necessary before definite conclusions can be drawn.

The results of two years' field tests with treated seeds of Sudan grass indicate that definite improvement of seedling stands occurs when seeds are treated with Spergon or Arasan. Tests with Semesan conducted during 1942 were also promising. The results of these tests are shown in Table 18. A preliminary note on some of the field tests was prepared and submitted for publication (Page 70). An abstract pertaining to some of the seed treatment work was prepared and data presented at the American Society of Agronomy meetings (Page 70).

Greenhouse Studies on Damping-off. As pointed out in the 1942 Annual Report (Page 58) discrepancies were frequently observed between greenhouse and field tests with treated seeds. Some of the factors that might contribute to these discrepancies were investigated during the winter and spring of 1943.

Soil moisture was found to influence very decidedly the amount of damping-off in steamed soil inoculated with pathogenic cultures of Pythium. Least pre-emergence damping-off occurred at soil moisture levels of 15 per cent while more damping-off occurred at

Table 18. Results of field tests with fungicides for control of damping-off. (Pasture Research Laboratory in cooperation with the Pennsylvania Agricultural Extension Service.)

Seeds used	No. of tests	Date of planting	Average deviations from checks				Average stand of checks
			Spergon	Arasan	New Improved Ceresan	Yellow Cuprocide	
			%	%	%	%	%
		1943					
Alfalfa	18	March, April	+ 2.0	- 0.1	+ 2.8	+ 1.6	39.0
	11	May, June	+ 3.6	+ 1.1	+ 2.5	+ 2.3	40.0
		1943					
Red clover	20	March, April	+ 6.3	+ 1.8	+ 2.3	+ 2.9	34.0
	11	May, June	- 1.5	- 2.1	+ 5.5	+ 5.0	40.0
		1942					
Sudan grass*	3	April, May, June	+ 9.7	+ 7.7	- 0.3	+ 8.7	42.0
	4	Aug., Sept., Oct.	+ 12.0	+ 7.2	- 9.2	+ 3.5	39.0
		1943					
Sudan grass	6	May, June, July	+ 8.0	+ 7.7	- 10.2	- 1.5	46.0

* Semesan in 1942 for April, May and June + 13.7; for August, September and October + 9.0.

20 to 25 per cent moisture. A saturated soil inhibited germination of many seeds and predisposed some of those that did germinate to attack by the organism. Soil moisture failed to influence the efficacy of any fungicide. New Improved Ceresan appeared to be the most favorable treatment for alfalfa and red clover in all the tests. Seedling stands of Sudan grass were improved with Spergon, Semesan, DuBay 1205FF, and Yellow Cuprocide, but New Improved Ceresan was injurious to seeds of Sudan grass at all but the lowest moisture levels.

Experiments to test the influence of soil pH on damping-off of alfalfa, red clover, and Sudan grass are being continued. Soil pH was found not to influence appreciably the survival of Pythium in a compost mixture.

Sand cultures of alfalfa, red clover and Sudan grass were used to test the effect of nitrogen, phosphorus and potash on damping-off. No effect on damping-off was observed when a complete fertilizer or a combination of any two elements was used. All treatments gave better seedling stands than controls with no fertilizer treatment.

Viability Tests on Seeds of Alfalfa, Red Clover, Ladino Clover, and Sudan Grass Treated with Different Fungicides. One-ounce lots of each species were thoroughly mixed with excess quantities of the following fungicides: New Improved Ceresan, Semesan, Arasan, Yellow Cuprocide and Spergon. An untreated lot of seed was set aside as a control. All excess fungicide was removed by thorough screening of the seed and the samples were placed in the different containers for the tests. A preliminary germination test was conducted on 200 seeds from each sample immediately after the treatments were completed. The seed samples were then stored for further tests.

Samples were stored at 10° C. and at 25° C. At each temperature, samples were stored in cloth bags exposed to circulating air, cloth bags buried in wheat, and in corked bottles. In addition, one set of samples was buried in a sack of red clover at 25° C. All samples were stored at atmospheric humidity.

Germination tests were conducted at monthly intervals during the first eight months of storage. For the first four months of the test, duplicate samples of 50 seeds were removed from each set. One of the 50 seed samples was placed in a Petri dish containing moist filter paper for a germination test. The fungicide was washed from the second 50-seed sample before making the germination tests.

There was little difference in germination between washed or unwashed seeds. In later tests, duplicate 50-seed samples were germinated by placing unwashed seeds directly in a Petri dish as previously described while the other 50-seed sample was sown in a flat of steamed soil.

After approximately eight months only Sudan grass treated with New Improved Ceresan showed injury from seed treatment. Neither temperature, treatment, nor container appreciably influenced viability of treated stored seeds of alfalfa, red clover or Ladino clover during the first eight months of the test.

Selection for Resistance to Rust in Meadow Fescue

During the late summer of 1943 a severe epidemic of crown rust (Puccinia coronata) was observed in a nursery of meadow fescue. Plants that were not infected in the field were removed to the greenhouse for further testing. Each plant removed from the field was divided clonally and tested in triplicate by inoculating with urediospores from susceptible, infected plants. A few of the selections tested to date have shown tolerance or some resistance to the disease.

Observations and some experiments are being conducted to determine the factors responsible for securing an epidemic of crown rust under greenhouse conditions. Investigations to date have shown that temperatures of 72-80° F. are most favorable for maintaining the uredial stage of the parasite on susceptible plants in the greenhouse. Lower temperatures prevent rupture of the rust pustules and teliospores become the predominant spore form.

SUMMARY

COOPERATIVE ACTIVITY

After a lapse of two years the collaborators met in New York City July 27 and 28, 1943, to discuss changes in the research program of the Pasture Laboratory that have been contemplated or initiated since the last meeting and to discuss means of increasing the supply of forage in the Region. The pasture renovation experiments, seed treatment with fungicides to control damping off and a chemical procedure for isolating a proteinaceous concentrate from grass were prominent among the topics discussed. A committee appointed for the purpose drew up certain suggestions as to steps that might be taken to help meet the war need of greater forage production in the Region. A summary report of the meeting and suggestions of the committee were mimeographed and copies distributed to interested persons.

COOPERATIVE PROJECTS

Active cooperative projects have been established between the Laboratory and 10 of the 12 northeastern Agricultural Experiment Stations. Short progress reports on the projects may be found beginning on Page 3. As a result of the breeding activity,

four strains each of Kentucky bluegrass and orchard grass are available for increase and further testing. A few strains of white clover including Ladino and several strains of Colonial bentgrass are being tentatively increased for further testing. The renovation experiments show that it is possible to increase substantially the production of poor pastures, particularly during the season when bluegrass-bentgrass-white clover pastures are likely to be short. Other cooperative projects involve over-liming injury and chemical composition of pasture grasses.

RESEARCH AT THE LABORATORY

Cytogenetics and Breeding of Grasses

Data on number of seeds per panicle set under bag and with open-pollination were obtained from orchard grass plants of 19 introduced strains, one commercial seed lot, and several collections from pastures, fields and roadsides in Maryland and Virginia. The range among plants within strains was greater than among means of strains of each of these characters. There was some indication that plants from pastures were more self-fertile on the average than those from the introduced strains or from commercial seed. A decrease in fertility from I_1 to I_2 in orchard grass was found which was similar in magnitude to the decrease from parent to I_1 encountered previously.

In meadow fescue, self-fertility in general was low. A majority of the 257 plants set less than one seed per panicle and the maximum was 12 per panicle.

Significant differences in earliness of spring growth, amount of growth, type of growth, density of sod, percentage of white clover, recovery following clipping, and resistance to leaf spot were found among the 110 new strains of Kentucky bluegrass that are being evaluated in preliminary plots.

The severe winterkilling during the season of 1942-43 necessitated replanting in the spring of 1943 many of the inbred lines of orchard grass. In those cases where reserve seed is not available, the parental clones are being selfed again in the greenhouse this winter.

Progeny tests of Kentucky bluegrass yielded results similar to those that have been obtained previously. In the plot tests of 13 strains and two commercial seed lots of Kentucky bluegrass, the same strain proved superior in 1943 as in 1942. For the first time, a differential effect of clipping treatment upon clover percentage in the plots was demonstrated. This effect was shown in a significant clipping treatment x strain interaction for

percentage of clover at the August 2 clipping. Plots have been seeded that are designed to test the response of strains of Kentucky bluegrass to nitrogen fertilization with and without associated white clover.

On the basis of 1942 yields and disease reaction, 50 inbred lines of Sudan grass were chosen for continuation in 1943. Poor stands were obtained in many cases, but some selfed seed was secured from most of the lines. Over 2,000 individuals of the Tift strain were grown in 1943, and 48 were selected for inbreeding.

Natural crossing of 18.3 per cent was observed for Sudan grass using a progeny of 677 individuals obtained in an isolated block of red and non-red plants in 1942.

Using 25 selected lines of Sudan grass, highly significant differences between lines were obtained in the case of each of the four cuttings and of total yield. Commercial Tift outyielded all selfed lines, but in some cases the difference was not significant.

Fifteen groups of selected clones of meadow fescue and four of bromegrass have been planted in isolation plots for the production of new strains. Twenty-five first inbred generation progenies were established from selected plants of meadow fescue. A nursery of approximately 5,000 plants of bromegrass was established from seed obtained from various sources.

Studies of inheritance of young plant characters in orchard grass and timothy are being continued. F_3 progenies of the hybrid Poa compressa x P. pratensis were established in the field in the fall of 1943.

Studies of the effects of inbreeding upon meiotic irregularity in orchard grass were continued. Plants of the I_2 generation had an average of more than three times as high a frequency of univalents at metaphase I as their I_1 clone.

Two plants of meadow fescue collected from a wild population in central Pennsylvania were hexaploid ($2n = 42$).

The distribution at anaphase I of the extra set of seven chromosomes in autotriploid perennial ryegrass was found to be at random.

Autotetraploid plants of meadow fescue were obtained from colchicine treatment of germinating seeds.

Cytogenetics and Breeding of Legumes

Studies relating to the practical utilization of the self-fertility allele (S_f) in white clover have been continued in the greenhouse, and the program of incorporating this gene into desirable stocks

is being extended to Ladino clover. Both selfed and open-pollinated seed was harvested last summer from selected F_1 hybrids, all of which bore the S_f gene, in order to establish new lines and to test combining ability of the selected plants.

The frequency of different oppositional alleles was investigated further using two natural populations of white clover which occurred in isolated pasture areas in central Pennsylvania. The study was made by diallely crossing F_1 hybrids, all of which had one allele in common. In the first series where the original population was estimated at only a few thousand individuals, 73 per cent of the 49 alleles tested proved different, while in the second series, where the population approximated a few hundred thousand plants, 80 per cent of the 49 alleles tested were different.

The behavior of oppositional alleles in polyploids was investigated by diallely mating two corresponding F_1 progenies which had been derived from two sets of comparable 32- and 64-chromosome parents. The presence of four intra-sterile, inter-fertile groups in the 32 x 32 family together with the fact that all reciprocal backcrosses to both parents were compatible indicated that the 32-crhomosome parents had no alleles in common. Results with the 64 x 64 family, however, were more complicated. This F_1 generation segregated into three self-incompatible plants and 26 self-compatibles, and all intercrosses and backcrosses using the self-compatibles as males were compatible. On the other hand, certain crosses using the self-incompatibles as males were incompatible, which allowed at least six different group reactions to be distinguished. In order to explain these results an hypothesis has been developed, the principal feature of which is that plants bearing only two different alleles are self-incompatible whereas those bearing three or four alleles are self-compatible. With these plants there were observed two types of behavior never noticed with the 32-chromosome clover, namely, significant differences in seed set due to male influence and significant end-season increases in seed set.

New plantings of second and third generation inbred lines of white clover and second generation inbreds of Ladino and strawberry clover were started.

When severe winterkilling occurred in the 1942 nursery, some inbred lines were lost. Notes on those remaining showed highly significant differences between lines in survival. Selfed seed was obtained on some of the better survivors, particularly among the second generation inbreds.

Plots were established in 1943 from the 25 white clover plants that appeared the best among the 1941 series and also from 242 Ladino clover plants selected as the most vigorous and disease

resistant individuals in the 1941 planting. The study of combining ability with the good, medium, and poor selections from sod plots was continued with a new series of plots.

As a measure of relative nicking ability of inbreds and parents, a group of comparable F_1 hybrids was produced last winter in the greenhouse, and the resultant families were grown in the field as spaced individuals last summer.

From collections in 29 old pastures throughout the Northeast Region, over 3,000 seedlings and 405 cuttings of Ladino clover were planted in 1943 as a new source of breeding stocks.

The first matings under bee cages of eight selected white clover plants and eight Ladino plants were made in 1943, but due to winterkilling the seed yield was low.

Most data from the additional families segregating for both enzyme and glucoside factors supported the original hypothesis of single unlinked genes for these two characters, but some evidence suggested modifying factors and the possibility of linkage.

Families breeding true for both resistance and susceptibility to rust have been obtained.

From a cross between a virus-infected and a healthy plant of white clover, 2223 F_2 and backcross individuals were classified, and most of the evidence suggested that the presence of two dominant factors was responsible for the susceptibility to the disease.

Physiology and Composition of Pasture Plants

A protein concentrate has been prepared from surplus pasture grass and its use as a poultry feed is being investigated. A concentrate containing over 50 per cent protein and low in fibrous constituents may be made from high protein cuttings obtained in the spring and fall. Summer hay proved to be a poor source of the concentrate.

The effects of the length of light and dark periods on reproduction were studied in the greenhouse using four clones of orchard grass, six clones of white clover and one clone of Canada bluegrass. These species headed and flowered under a 16-hour day and 8-hour night. Similarly these species also headed and flowered under a 10-hour day when an additional one or two hours of light was supplied in the middle of the otherwise normal 14-hour night or at such other intervals that the dark periods did not exceed 6-1/2 hours in length. Under the natural 10-hour day and 14-hour night no heading of any of the grasses occurred and heading of the white clover was definitely limited. The vegetative responses of orchard grass and Canada bluegrass to daylength and to length of the dark period were similar to their heading

responses. The yield of herbage was increased almost as much by supplementary light from 12:00 midnight to 1:00 a.m. as by six hours of supplementary light supplied at the end or beginning of the natural 10-hour winter day. The yield of herbage from plants receiving no supplementary light was approximately one-third of that obtained when supplemental light was provided.

In another experiment the effects on vegetative growth of length of day and length of night varied widely with different species. With bromegrass and perennial ryegrass the total yields of dry matter were largely independent of the length of day. Birdsfoot trefoil made very poor growth under natural day (9 to 10 hours) but gave progressively higher yields as the length of day was increased to 11, 13, 15, and 17 hours. Kentucky bluegrass made less growth under the 17-hour day than under any other treatments. Red clover grew best under a 17-hour day. In orchard grass, the response to two hours of light at midnight was similar to that obtained under a 15-hour day.

Eight diploid clones of perennial ryegrass and the eight tetraploid clones obtained from the diploid by colchicine treatment were grown in soil and gravel culture in the greenhouse under two frequencies of defoliation. Reduplication of chromosomes in all cases reduced the number of tillers produced. In most cases, the yield of roots, tops and stubble was greater in the diploid than in the related tetraploid clone. In some comparisons, however, the reverse was true depending upon the gene base reduplicated, the medium in which the plants were grown, and the clipping treatments used.

Diploid and tetraploid ryegrass plants did not differ in their cellulose and lignin contents.

The effects of air and soil temperatures on the emergence and early seedling growth of three legumes and five grasses were studied under controlled conditions. In addition to determining the optimum air and soil temperature range for each species, some of the effects of maintaining soil temperatures 10° F. lower than air temperatures were observed. Air temperatures of 80° to 95° did not exhibit particularly deleterious effects on growth if the soil temperature was maintained 10° F. below the air temperature. At air temperatures below the 80° to 95° range, a decrease of 10° F. of the soil temperature below the air temperature in most instances increased the proportion of the roots produced in relation to the tops. With a decrease in the air and soil temperatures, except at the upper extreme where the plants were severely injured, an increase in the root-top ratio generally occurred.

The growth and recovery of perennial ryegrass after clipping was studied at four temperatures. New leaf growth was greatest at a night temperature of 60° F. and a day temperature of 70° F. and least at a night temperature of 80° F. and a day temperature of 90° F. After clipping, the stubble and roots decreased in dry weight at all temperatures, but most rapidly at high temperatures. Likewise, soluble carbohydrates decreased in the stubble and the roots, the decrease being most rapid at the higher temperatures. By the end of 40 days after the clipping date, restorage of carbohydrates was beginning at lower temperatures but not at higher temperatures.

Greenhouse studies with Kentucky bluegrass showed large clonal differences in total yield of dry matter as well as in the ratios of tops, stubble, roots, and rhizomes. Clonal differences in response to nitrogen fertilization were less marked than differences due to clipping treatments.

Preliminary trials indicate that nitrogen fertilizer applied to a Kentucky bluegrass sod increased the rate of infiltration of water.

A modification of the method for determining hydrocyanic acid in white clover has been studied. The necessity for supplementing the enzyme activity of the plant with added enzyme was confirmed.

The inhibiting effects of steam sterilization of certain soils on the growth of plants were overcome by heavy applications of phosphate fertilizer. Apparently, however, the injury was not due primarily to a deficiency of available phosphate.

Pathology

Chlamydospores of Ustilago striaeformis from leaves of Kentucky bluegrass and redtop responded to afterripening at 35° C. more readily than chalmydospores from smutted leaves of orchard grass and timothy. Afterripened chlamydospores retained their viability when stored dry at low temperatures. Smutted leaves of Kentucky bluegrass that were surface sterilized and then stored in a moist chamber at 35° C. yielded germinable chlamydospores in five to 30 days. Fresh smut chlamydospores free of the host tissue were successfully afterripened. Preliminary studies on seed transmission of stripe smut in timothy indicated that infection probably may occur from spores lodged on the surface of the seeds.

Results of 60 field tests conducted in 18 counties of Pennsylvania with treated seeds of alfalfa and red clover indicated that some

fungicides may prove valuable for improving stands of forage crops. Seeds of Sudan grass treated with Spergon or Arasan have given increased stands in tests for the past two years.

Greenhouse tests showed that higher soil moistures favored damping-off but that variations in soil moisture failed to influence the efficacy of any fungicide. New Improved Ceresan was most effective in controlling pre-emergence damping-off of alfalfa and red clover in the greenhouse.

Although fertilizer treatment resulted in better stands than the control, none of the treatments provided adequate protection from damping-off in alfalfa, red clover or Sudan grass. Neither did fertilizer treatments affect differentially the efficacy of any fungicide tested.

Seeds of alfalfa, red clover, and Ladino clover treated with different fungicides and stored under a variety of conditions were not appreciably injured by any of the fungicides tested. New Improved Ceresan was injurious to Sudan grass after a relatively short period.

Several plants of meadow fescue tested in the greenhouse for resistance to crown rust have shown tolerance to the disease.

LIST OF PUBLICATIONS

PUBLISHED

Atwood, Sanford S. "Natural crossing" of white clover by bees. Jour. Amer. Soc. Agron. 35:862-870. 1943.

Atwood, S. S., and Sullivan, J. T. Inheritance of a cyanogenetic glucoside and its hydrolyzing enzyme in Trifolium repens. Jour. Heredity 34:311-320. 1943.

Chilton, S. J. P., Henson, L., and Johnson, H. W. Fungi reported on species of Medicago, Melilotus, and Trifolium. USDA Misc. Pub. 499. 1943.

Kreitlow, K. W. Ustilago striaeformis. I. Germination of chlamydospores and culture of forma agrostidis on artificial media. Phytopathology 33:707-712. 1943.

Kreitlow, K. W. Ustilago striaeformis. II. Temperature as a factor influencing development of smutted plants of Poa pratensis L. and germination of fresh chlamydospores. Phytopathology 33:1055-1063. 1943.

Kreitlow, K. W. Investigations on seed treatment of forage grasses and legumes for control of damping-off. USDA Plant Dis. Reptr. 27:111-112. 1943.

Myers, W. M. Analysis of variance and covariance of chromosomal association and behavior during meiosis in clones of Dactylis glomerata. Bot. Gaz. 104:541-552. 1943.

Myers, W. M. Second generation progeny tests of the method of reproduction in Kentucky bluegrass, Poa pratensis L. Jour. Amer. Soc. Agron. 35:413-419. 1943.

Myers, W. M., and Hill, Helen D. Increased meiotic irregularity accompanying inbreeding in Dactylis glomerata L. Genetics 28:383-397. 1943.

Sprague, V. G., and Williams, E. M. A simplified integrating light recorder for field use. Plant Physiology 18:131-133. 1943.

Sullivan, J. T. Differential action of permanganate and ceric sulfate on cuprous oxide prepared in presence of iodide. Jour. Assoc. of Off. Agr. Chem. 26:428-429. 1943.

Sullivan, J. T. Protein concentrates from grasses. Science 98:363-364. 1943.

Sullivan, J. T., and Chilton, S. J. P. The composition of white clover leaves as affected by rust and by sulphur. Phytopath. 33:401-402. 1943.

Sullivan, J. T., and Sprague, V. G. Composition of the roots and stubble of perennial ryegrass following partial defoliation. Plant Physiology 18:656-670. 1943.

Wernham, C. C., and Chilton, St. John P. Typhula snowmold of pasture grasses. Phytopath. 33:1157-1165. 1943.

PAPERS PREPARED FOR PRESENTATION DURING 1943 BEFORE PROFESSIONAL SOCIETIES

Atwood, S. S. Self- and cross-incompatibility in polyploids. Presented at meetings of the American Society of Agronomy, Cincinnati, Ohio. November 10-12, 1943.

Kreitlow, K. W., and Garber, R. J. Effect of seed treatment with certain fungicides on seedling stands of alfalfa, red clover, and Sudan grass and on viability of stored seeds. Presented at meetings of the American Society of Agronomy, Cincinnati, Ohio. November 10-12, 1943.

Myers, W. M. Increased meiotic irregularity and decreased fertility accompanying inbreeding of Dactylis glomerata. Presented at meetings of the American Society of Agronomy, Cincinnati, Ohio, November 10-12, 1943.

Sprague, V. G. The effects of temperature and daylength on growth during the seedling stage of several pasture grasses and legumes. Presented at meetings of the American Society of Agronomy, Cincinnati, Ohio, November 10-12, 1943.

MANUSCRIPTS PENDING

Atwood, Sanford S. The behavior of oppositional alleles in polyploids of Trifolium repens.

Atwood, Sanford S. Colchicine induced polyploids in white clover.

Atwood, Sanford S. Oppositional alleles in natural populations of Trifolium repens.

Kreitlow, K. W., and Myers, W. M. Prevalence and distribution of stripe smut of Poa pratensis L. in some pastures of Pennsylvania.

Myers. W. M. Cytological studies of triploid perennial ryegrass (Lolium perenne L.) and its progeny.

Myers, W. M. The randomness of chromosome distribution at anaphase I in autotriploid Lolium perenne L.

Myers, W. M. Cytological and genetic analysis of chromosomal association and behavior during meiosis in hexaploid timothy (Phleum pratense L.).

Robinson, R. R. Plant growth on partially sterilized soil.

Sprague, V. G. The effects of temperature and daylength on seedling emergence and early growth of several pasture species.

Sullivan, J. T. A modification of the procedure for the analysis of white clover plants for hydrocyanic acid.

Sullivan, J. T. The preparation of a high-protein concentrate from grass.

Sullivan, J. T. Further comparisons of plants with different chromosome numbers in respect to chemical composition.

Appendix

(The responsibility for compiling each state report was assumed by the collaborator of that state)

PROGRESS REPORT OF STATE STATIONS

CONNECTICUT (STORRS) AGRICULTURAL EXPERIMENT STATION

Title: Alfalfa Experiments.

Leaders: B. A. Brown and R. I. Munsell.

a. Response to Soil Treatments. Recent data indicate that longevity and yields are increased by annual applications of potash over single heavy, preseeding, disked-in treatments. Frequent limings at moderate rates have been beneficial on plots limed heavily enough before 1929 to equalize the reactions of the subsurface and surface soils.

c. Effects of Amount and Depth of Applying Limestone. In the second harvest year since reseeding, alfalfa, on plots that received limestone at three tons in 1933 and none since, yielded about the same as on other plots with one-third the initial applications, plus small additions in 1941. Earlier results showed that alfalfa may be grown successfully on acid soils with much less lime than commonly recommended provided it is spread at or near the surface. The long continued practice of light, frequent limings will probably result in more acid, base deficient subsoils and this may be unfavorable to a deep-rooted crop like alfalfa.

d. The Role of Minor Elements in Fertilizing Alfalfa. After five years since a single application of borax at 20 pounds and after the removal of eight cuttings of hay, only four per cent of the alfalfa showed symptoms of boron deficiency during the very severe drought of August-September 1943. Manure at 10 tons per acre, annually, reduced the prevalence of deficiency symptoms from 29 to 11 per cent. The boron content of the two 1942 cuttings of alfalfa was raised from 28 to 36 p.p.m. by the borax application of 1938, but manured alfalfa did not contain any more boron than that with neither manure nor borax. Under normal soil conditions, stands and yields of dry matter have not been affected appreciably by applications of borax. (See report on over-liming project, Page 6.)

On the same dates and under the same conditions, some strains and varieties of alfalfa have shown more boron deficiency than others. This may have been due partly to difference in stage of development.

During 1943, Mn, Cu and Zn have had no apparent effects on alfalfa on Charlton fine sandy loam soil of the Station Farm.

On several dairy farms with sandy soils, both stands and yields of alfalfa were greatly improved in August 1943 by borax at 20 pounds applied as top-dressing in April 1940. In 1942, the average B content of alfalfa on these farms was increasing about 50 per cent by the borax application of 1940.

Analyses of the voidings of a dairy cow showed that the dry matter of the solid part contained 25 p.p.m. of boron, while the liquid portion partially dried at 100° C., contained 53 p.p.m. From these analyses, it has been estimated that the annual voidings of a 1000-pound cow would contain approximately 0.09 pound of boron, the equivalent of 0.8 pound of borax, only about half the amount contained in three tons of alfalfa hay. No doubt, voidings from animals fed boron rich roughage would contain more boron than the cited amounts.

Title: The maintenance and Improvement of Pastures.

Leaders: B. A. Brown and R. I. Munsell.

a. The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing. Because frequently applied nitrogenous fertilizers had failed to alleviate appreciably the usual shortage of feed from permanent pastures after June 15, several of the 2-acre grazed plots in the Cummings pasture experiment are now being devoted to a study of methods of establishing legumes, particularly Ladino clover, on this rocky land. Disking plus heavy spring grazing to subdue the grasses, gave the best stands of clover in the first year (1943), although seeding with no tillage on a plot with a thin, weedy turf, due to a previous lack of P, also had a promising stand of Ladino clover in August 1943. An extremely dry summer and early fall was unfavorable for the newly established Ladino clover.

Birdsfoot trefoil was seeded on one pasture but no plants were seen throughout the first season.

c. The Effects of Various Chemicals on the Soil, on the Botanical Composition of the Sward, and on the Stands and Growth of Kentucky Bluegrass and Rhode Island Bentgrass. No new data in 1943.

d. The Adaptability of Varieties and Species of Grasses and Clovers for Pastures. The winter of 1942-43 was unusually cold, with almost record breaking minimum temperatures in both December and February. Such conditions afforded a good test of the hardiness of the many species, varieties and strains of grasses and legumes on the Agronomy plots.

In May 1943 none of eight strains of perennial ryegrass (Lolium perenne) had over 25 per cent stands. Under the same conditions, six strains of orchard grass averaged 64 per cent, and 18 strains of timothy, 73 per cent survival. Even with the relatively hardy

timothy, the tests indicate the inadvisability of obtaining seed of strains bred or developed under much more mild temperatures than those existing in the region where the seed is to be sown.

Rhode Island bentgrass on lawnmowed plots also suffered considerable winterkilling. The stands of Kentucky bluegrass were not reduced under any of the existing conditions. Redtop, smooth bromegrass and tall fescue showed no evidences of winterkilling.

Ladino clover winterkilled badly when it comprised most of the stand and especially on the wetter areas. Most Ladino clover losses appear to have been due to "heaving" of the soil.

In most cases, alfalfa came through the winter with good stands, even when in pure culture. On moist spots, however, some loss by heaving occurred. As in the case of Ladino clover, the presence of grass with alfalfa prevented most of the losses by heaving of the soil. Alfalfa strains, very susceptible to "leaf spot" in the late summer and fall of 1942, had the greatest reductions in stands during the winter.

The management studies of two Ladino clover-grass seedings have now completed four entire harvest seasons. The average number of cuttings per season has varied from three to seven.

At the close of the 1943 season, Ladino clover averaged for all systems of cutting about one-third of the area, with extremes of 22 and 40 per cent. The more frequent and closer to the ground systems of cutting have favored Ladino clover in its competition with either timothy or orchard grass, but such cuttings have resulted in somewhat more volunteer bluegrass, especially in the Ladino clover-timothy seedings.

It is evident that Ladino clover will maintain fairly good stands for at least four years under a variety of cutting treatments provided it is adequately fertilized with minerals.

The yields of dry matter have been largest where the first cutting was deferred until June 1 for orchard grass-Ladino clover and to June 15 for the timothy-Ladino clover mixtures, but these larger yields of dry matter have contained enough smaller percentages of protein to bring their yields of protein down to less than those obtained from the straight 6-2 inch system, i.e., cut to two inches when the grass was six inches high. (In 1941 and 1942, the deferred first cutting and 6-2 inch systems each averaged over 1,000 pounds of protein per acre.) The deferred first cutting system furnished more June but less summer feed.

The lowest yields of dry matter resulted from cutting four rather than two inches above the ground, regardless of interval between cuttings, or from not cutting after September 1.

f. Causes of Fluctuations in the Prevalence of White Clover.

Liberal potash fertilization continued to be of prime importance in maintaining white clover in grassland. Results indicate that Ladino clover is favored in its competition with Kentucky bluegrass if P is not added as liberally as K. Annual applications of K have given better stands and growth than single, large, preseeding treatments.

Extremely dry soil conditions have caused very large and rapid decreases in the prevalence of white clover regardless of fertilization or competition from other species. Many experimental examples of this were noted in 1943, which, for the June-September period, was the second driest at Storrs in fifty-five years.

DELAWARE AGRICULTURAL EXPERIMENT STATION

Title: Pasture Management and Milk Production.

Leaders: C. E. Phillips, T. A. Baker, and A. E. Tomhave.

Three years' results have been secured on this project. Periods of severe drought have occurred in all three years. In 1941 and 1943 dry weather occurred in the latter part of the season and the cows were taken off pasture early in September. In 1942 the drought was in midsummer and the cows were off pasture during the month of July.

An average of results for three years shows that the Ladino clover paddock has produced 17,240 pounds of green grass per acre and 184 cow days per acre of grazing; Kent wild white clover paddock, 7,813 pounds and 99 cow days of grazing; commercial white Dutch clover, 7,216 pounds and 83 cow days of grazing; and Korean lespedeza 11,986 pounds and 145 cow days of grazing.

The table below shows the distribution of the production by months.

Table 19. Distribution of yield by months from pasture paddocks containing four legumes.

Paddock	Green grass available in pounds per day				
	May	June	July	August	September
Ladino clover	250.0	108.0	97.6	63.5	38.2
Kent wild white clover*	89.7	74.2	49.7	25.2	14.9
Commercial white Dutch clover	94.2	70.4	37.5	21.3	10.9
Korean lespedeza	135.8	72.6	75.8	69.1	33.3

* The Kent wild white and commercial white Dutch clovers both winterkilled in the winter of 1941-42. Native white clover has come in and the two paddocks have been essentially the same for the past two seasons.

The average comparative milk production for the three years is: Barn-fed 100, pasture plus supplementary grain 103, and pasture alone 90.

Title: The Adaptation and Use of Improved Strains of Grasses.

Leader: C. E. Phillips.

A number of strains of several species of grass were planted in two locations in the fall of 1942. At Newark the soil was a silt loam, and in Southern Delaware, at Georgetown, the soil was a sandy loam. Preliminary observations on row plots are given below:

Newark:	Kentucky bluegrass	- Primo, best of 14 strains.
	Red fescue	- Quebec, best of 2 strains.
	Orchard grass	- Brage, best of 7 strains.
	Perennial ryegrass	- Jaersk, best of 9 strains.
	Timothy	- Milton, best of 9 strains.
	Smooth bromegrass	- B-10, best of 10 strains.
	Reed canary grass	- 2756, no better than commercial.
	Tall fescue	- 2659, slightly better than alta.
	Redtop	- 7163, better than commercial.
	Canada bluegrass	- All poor compared to Kentucky bluegrass.
	Italian ryegrass	- 2732 (Veibulls), best of 5 strains.
	Crested wheatgrass	- NY-28 and NY-35, not promising.
	Bromus arvensis	- Better than Italian ryegrass.
	Bromus marginatus	- Good growth.
Georgetown:	Kentucky bluegrass	- Veibulls, best of 14 strains.
	Red fescue	- Quebec, best of 2 strains.
	Orchard grass	- Brage, best of 7 strains.
	Perennial ryegrass	- Otofte and R-2, best of 9 strains.
	Timothy	- Cornell 4059, best of 9 strains.
	Smooth bromegrass	- B-12, best of 10 strains.
	Reed canary grass	- 2756, no better than commercial.
	Tall fescue	- 2659, better than alta.
	Redtop	- 7163, not better than commercial.
	Canada bluegrass	- All very poor.
	Italian ryegrass	- R-4, best of 5 strains.
	Crested wheatgrass	- Not promising.
	Bromus arvensis	- As good as Italian ryegrass.
	Bromus marginatus	- Good growth.

The species showing the most promise in the dry weather generally prevailing last year were reed canary grass, smooth bromegrass, tall fescue and orchard grass.

Title: Evaluating Ranges for Poultry.

Leaders: Edmund Hoffmann and Claude Phillips.

The value of poultry range in reducing the cost of growing pullets by making it possible to feed a cheaper ration was studied in 1943. The previous two years' results had shown that the possible saving in total feed consumption by using good range was in the neighborhood of five per cent so it seemed advisable to shift from a quantitative to a qualitative approach to the problem.

After two years of use, the alfalfa range had a 40 per cent stand, the rest being weeds, the grass and Ladino clover range had become all grass, but the pure Ladino clover and the mixed grass ranges still had 85 per cent stand. A bare ground plot and a group of pullets in a 10 x 12 colony house provided with a wire sunporch were used as controls.

The control groups were fed a complete diet. The groups on Ladino clover, alfalfa, and grass range were fed a diet composed of grains, soybean oil meal and minerals and had to depend on the range as a source of vitamins A (carotene), riboflavin and the other water soluble factors. The minerals were omitted from the diet of the other grass plot. Table 20 summarizes the reponse of the pullets on the ranges.

It seems clear that the poultry range supplied enough Vitamin A (carotene), riboflavin and the other water soluble factors for normal growth under the conditions of this experiment. However, the high mortality and slow growth of the low mineral grass group would indicate that some supplementary minerals besides those that occur naturally in feedstuffs must be fed to pullets on range.

During the summer of 1943 the poultry ranges were subjected to the worst drought to date, but this did not change their relative value in providing the most days of luxuriant range. The Ladino clover range stood up best under the summer heat. The alfalfa range was an indifferent second and the predominantly bluegrass ranges dried up completely in August and furnished very little palatable grazing.

As in previous years the Ladino clover seemed to be the most palatable. Many birds could be seen eating the leaves and in a given square foot of range slightly more than 50 per cent of the leaves were partly consumed.

After three years of use the Ladino clover range was clearly superior to the other ranges for raising pullets as measured by days on luxuriant condition, maintenance of stand, and palatability.

Table 20. Summary of the growth, feed consumption and livability of pullets on various ranges.

Range	Grass	Ladino clover	Grass	Alfalfa	Bare ground	Confinement
Feed	Low A and riboflavin	Low A and riboflavin	Low A, riboflavin and minerals	Low A and riboflavin	Complete diet	Complete diet
Final average weight per pullet	4.65	4.84	4.46	4.59	4.44	4.50
Average gain per pullet on range	3.65	3.81	3.42	3.60	3.49	3.44
Feed consumed per pullet	25.76	26.35	27.79	25.12	25.25	28.13
Pounds of feed per pound of gain	7.05	6.89	8.10	6.97	7.21	8.20
Per cent livability	90.0	91.6	71.6	90.0	91.6	95.0

Although differences were not significant, growth was most rapid and feed consumption per pound of gain was lowest on the Ladino clover range.

MAINE AGRICULTURAL EXPERIMENT STATION

Title: Grassland Studies.

Leader: J. A. Chucka.

The grazing experiment at Highmoor Farm was continued. The calculated yields in terms of milk per acre are lower than they should be for the past season. This is because the paddocks were undergrazed during May and June. The Ladino clover-bromegrass paddock produced the highest yield of milk. The cows appeared to like the Ladino clover-bromegrass combination and always came up in milk production to the extent of one to two pounds of milk per cow per day when transferred from the Kentucky bluegrass paddock to the Ladino clover-bromegrass paddock.

The frequency of rains during August and September made it impossible to harvest Ladino clover seed in Maine during the past season.

Top-dressing pastures with 50 and 100 pounds of nitrogen per acre in the form of ammonium nitrate resulted in good increases in yield of pasture herbage and also increased the percentage of nitrogen in the herbage. The data secured are shown in Table 21 and indicate the response to nitrogen that may be expected from midsummer top-dressing of pastures during seasons of sufficient rainfall.

Grass silage from Ladino clover-timothy stands was put up with and without phosphoric acid as a preservative at Highmoor Farm last summer. The vegetation going in both silos was wilted to about 30 to 35 per cent dry matter content before ensiling. No appreciable difference in quality of the silage coming out of the two silos has been observed thus far which indicates that satisfactory grass silage can be made without the addition of a preservative.

MARYLAND AGRICULTURAL EXPERIMENT STATION

Title: Methods of Improving Permanent Pastures on the Several Soil Provinces in Maryland.

Leader: W. B. Kemp.

Again in 1943 as in several earlier years, a number of pastures of different species and different fertilization were caged to obtain estimates of both absolute production and distribution of

Table 21. Effect of ammonium nitrate applied as a pasture top-dressing July 17, 1943

Cutting date	Treatment pounds per acre of nitrogen	*Yield, pounds per acre		Per cent nitrogen	Protein pounds per acre
		Green grass	Dry matter		
8/6/43	0	838	202	3.39	42.8
	50	1777	397	3.78	93.7
	100	2607	508	4.16	132.1
8/27/43	0	1133	270	3.55	59.9
	50	1878	425	3.81	101.1
	100	3111	631	4.10	161.7
9/20/43	0	1066	259	3.56	57.6
	50	1121	287	3.57	64.1
	100	1583	377	3.82	89.9
Total of three cuttings	0	3038	731	3.51	160.3
	50	4776	1109	3.74	258.9
	100	7301	1516	4.05	383.7

* The yields are based on averages of six replicate plots each 5' x 5' in size.

production throughout the growing season. A few pastures have been caged each year to permit observations of the effects of differences in season on the production pattern.

In 1942, several dairy farms were chosen for complete records of the pasture pattern from all crops, the total feed consumption, milk production and changes in animal weights. In 1943, only two farms were chosen for detailed records. On one of these farms, year-round barn feeding of alfalfa hay, corn silage, and concentrates was practiced with no pasture. On the other, a normal program was followed. Due to the very severe drought which prevailed, only 24 per cent of the digestible nutrients on this second farm were obtained from pasture with an average consumption per cow of 20.4 pounds of hay equivalent per day for 158 pasture days. Even then it was necessary to pasture on the second and third cuttings of alfalfa and to provide some hay and silage during the summer. Both herds consisted of purebred and grade Guernseys. Production was corrected for time of freshening and was adjusted to four per cent milk equivalent.

In comparison with the herd exclusively barn fed, the herd on pasture consumed 2.8 per cent more T.D.N. or 6314 pounds during the year, maintained 10 per cent greater mean animal weight or 1048 pounds, produced 18 per cent more milk or 8614 pounds, and produced four per cent more milk for each pound of T.D.N. consumed or 1.36 pounds.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

Title: Experiments at Amherst with Hay and Pasture Seeding Mixtures.

Leader: W. G. Colby.

Three years' results from these experiments are now being summarized preparatory to publication.

Title: A Study of the Response of Different Hay and Pasture Seeding Mixtures to Heavy Nitrogen Fertilization.

Leader: W. G. Colby.

In the early spring of 1943, nitrate of soda was applied at the rate of 450 pounds per acre to half of each plot in the series with different seeding mixtures. These plots, seeded in the summer of 1940 and described in the Annual Report for 1941, Page 71, made it possible to study the effect of liberal nitrogen fertilization on a number of the more important pasture grasses, both in stands made up largely of grass and also with varying amounts of clover, chiefly Ladino clover. The following results may be of interest.

Rate of Application. For conditions as they existed, 450 pounds of nitrate of soda supplied too much nitrogen for best results. The weather during the spring months, particularly May, was much wetter than usual, so that the growth response to nitrogen was abnormally large. Serious lodging occurred in many of the hay plots, and in several of the pasture plots for a time feed was produced at a faster rate than could be efficiently utilized. Under the circumstances, it is probable that 50 pounds of elemental nitrogen to the acre would have been more satisfactory than 75 pounds.

Dry Matter Yields. Because of extensive lodging in the plots cut first for hay, only yields from the pasture series will be considered.

The first harvest on the pasture plots was made on May 27th. Increases in yields as a result of nitrogen fertilization varied from nothing, in the case of a poor stand of perennial ryegrass and Ladino clover, to over a two and one-half times increase in yield from a practically pure stand of timothy. The average increase in yield from applied nitrogen for the nineteen different seedings was 51.3 per cent.

For the second harvest on June 29th, yields of the nitrogen half of the plots varied from a minus 22 per cent for the redtop-Ladino clover plot to a plus 78 per cent for a practically pure timothy stand. The average increase for all plots was 5.4 per cent. The decrease in yield in the case of redtop is explained by the fact that the clover population was greatly reduced in the fertilized half of the plot. In the no-treatment half of the plot where there was a fairly good stand of clover, yields were well maintained throughout the season.

The results obtained at the time of the third harvest on July 30 were similar to those obtained for the second. Some plots showed slight increases, while others showed small decreases. Ninety-four per cent of most of the increase in yield from additional nitrogen was obtained at the first harvest date in May.

Response of Different Grasses. Timothy produced the greatest response to nitrogen fertilization followed in turn by smooth bromegrass, Kentucky bluegrass, redtop, meadow fescue, perennial ryegrass, and orchard grass. In the case of timothy, the average increase in yield for four different strains (fairly pure stands) was 82.6 per cent for the first harvest, 28.1 per cent for the second, and 4.9 per cent for the third.

Effect of Nitrogen on the Clover Population. The effect of nitrogen on the clover population varied greatly with different grasses. Redtop gave the poorest results. When redtop was present to an appreciable extent, additional nitrogen tended to strongly suppress the clover. For example, the redtop-Ladino clover plot was made up

of 80 per cent redtop and 20 per cent clover in the spring. By fall the nitrogen half of the plot had only 10 per cent clover, while the untreated half contained 60 per cent clover. Kentucky bluegrass behaved similarly to redtop.

Tall fescue and orchard grass had already crowded out much of the Ladino clover before nitrogen was applied. Additional nitrogen merely resulted in the elimination of what little cover was left.

Bromegrass in the pastured plots gave good results. Additional nitrogen, though it increased yields appreciably, had no deleterious effect on the clover. The clover population at the end of the season was about 60 per cent on both the treated and untreated halves of the plot. In the bromegrass plots cut for hay, however, the results were very different. Nitrogen caused extensive lodging before cutting with the result that practically all of the clover was smothered out. Since nitrogen had no noticeable effect on clover population in the bromegrass plots which were pastured, it is obvious that the elimination of the clover in the hay plots was due largely to the lodging and not to increased competition from the grass.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

Title: A Study of Pasture Species under New Hampshire Conditions.

Leaders: Ford S. Prince, Leroy J. Higgins and Paul T. Blood.

During the year the original project was divided into two phases, testing and breeding with respect to forage crops. The testing work is being continued as Bankhead Jones No. 3, while the breeding work now comes under the heading of Bankhead Jones No. 14, entitled, "The Improvement of Ladino Clover, Red Clover and Timothy by Selection and Breeding", and is reported on Page 21.

The testing work in 1943 dealt mainly with strains of grasses sent to us from different sources, including uniform grass nursery material, but included also certain native selections.

In attempting to evaluate these grasses, two harvests were made from the rod rows in which they were seeded. These cuttings were made in June and again in early September. These studies included 57 strains of timothy, 11 of Kentucky bluegrass, eight of smooth bromegrass, seven each of meadow and tall meadow fescue, orchard grass and red fescue, four of bentgrass, and three of meadow foxtail.

Meadow and tall meadow fescue produced the highest average yields. This species was followed in total yield of two harvests by orchard grass, bentgrass, smooth bromegrass, red fescue, timothy and

Kentucky bluegrass. (No yields were available on meadow foxtail.) The differences in total yield were due more to the second than the first cuttings.

Title: Producing the Full Roughage Requirements on New Hampshire Dairy Farms (with Special Reference to Pastures).

Leaders: Ford S. Prince and Paul T. Blood.

This project was begun in 1942 and involved, amongst other things, the reseeding of old pastures or seeding crop land to pasture. Seedings included one or more of the following grasses with Ladino clover: Orchard grass, smooth bromegrass, reed canary grass, tall meadow fescue, perennial ryegrass and two strains of timothy, Milton and Cornell 1777.

The areas so seeded were all managed as pasture part or all of the 1943 season. Since all areas had presumably been fertilized adequately in 1942, no lime, superphosphate or potash was used in 1943. Several of the pastures were divided crosswise, however, and nitrate of soda was applied at one, two, or three levels, to note the influence of nitrogen on yields as well as its effect on the persistence of Ladino clover.

Eight of the areas were caged and harvested throughout the season. These harvests included two of the pastures in which nitrogen had been applied at different levels.

The influence of Ladino clover on yields was so strong in 1943 that the application of nitrogen in any amount had very little effect in yield. There was some difference in plot yields representing the different grasses. In so far as possible these have been averaged in table 22 and listed in a descending order.

Table 22. Average yield of grasses and pounds per acre of oven dry material.

Grass	Yield
Reed canary grass	5866
Timothy	5697
Tall fescue	5613
Orchard grass	5413
Smooth bromegrass	5211
Perennial ryegrass	5175

In a rate of seeding test in which orchard grass was seeded at the rate of 3, 6, and 9 pounds with Ladino clover, the yields were as follows:

Rate of seeding	Yield per acre
Orchard grass 9	6210
" " 6	5548
" " 3	4908

This would indicate the need for at least nine pounds of orchard grass with two pounds of Ladino clover where other grasses are not included in the mixture.

The results as quoted do not give the seasonal distribution of the forage, which is an important point in our farming system. Observation and the estimates of farmers on whose farms the plots are located would appear to indicate that yields in late July and August of these grasses would run about as listed, with exceptions from pasture to pasture; Reed canary grass, tall fescue, orchard grass, smooth bromegrass, with timothy and perennial ryegrass about equal, although in late season the perennial ryegrass appeared to come back somewhat more than timothy.

Some of these tests were studied with a view of estimating the amount of competition each grass offered to Ladino clover. Ranking from greatest to least in 1943 we would list these as perennial ryegrass first with reed canary grass, orchard grass, tall fescue, smooth bromegrass and timothy following in about the order named.

From observation of grazing habits it would seem that smooth bromegrass is the most palatable, followed closely by timothy, then orchard grass, reed canary grass, perennial ryegrass and tall fescue. Differences in palatability were more noticeable in early season. In midsummer, when there was a deficiency of feed in most cases, all the grasses were well eaten.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Title: Beef Cattle Pasture Experiment with Orchard Grass.

Leaders: Gilbert H. Ahlgren and George Van Der Noot.

An orchard grass pasture of 22.5 acres divided into five paddocks of equal size has been receiving the fertilizer treatments given below. Some paddocks have a legume growing with the orchard grass and this is also indicated. The treatments are given annually.

Paddock 1. Ladino clover plot. Manure and 400 pounds of 0-20-20 fertilizer per acre.

Paddock 2. Heavy nitrogen. 1,000 pounds of 5-10-5 per acre.

Paddock 3. Birdsfoot trefoil. Manure and 400 pounds of 0-20-20 per acre.

Paddock 4. Kent white clover. Manure and 400 pounds of 0-20-20 per acre.

Paddock 5. Control. Given 400 pounds of 5-10-5 per acre.

These paddocks were over-grazed this past season due to the extreme hot dry weather which limited grass production. It is not felt that data on these plots are representative as a result of the over-grazing and, therefore, none is presented. An attempt is being made to secure a supplemental pasture area and thus be able to avoid in the future difficulties encountered last summer.

Title: Comparative Yield Test of 13 Grasses under 2 Cutting Treatments.

Leader: Gilbert H. Ahlgren

This test was seeded in August 1942 and consists of the following grass species: Meadow and alta fescue, timothy, reed canary grass, bromegrass, tall oat grass, Kentucky and Canada bluegrass, Italian and perennial ryegrass, redtop, red fescue, and colonial bentgrass. It was originally intended that legumes be included in this study but failure to secure a stand is responsible for their omission.

One-half of each plot was cut at every 2-week interval throughout the season to simulate close grazing; the other half was permitted to reach a height of four to six inches before being cut back. All samples were taken using a regular lawn mower. The summer season at New Brunswick was exceptionally hot and dry.

The regularly clipped plots yielded from 60 to 70 per cent of the season's growth during May to the middle of June. Deferred cutting resulted in between 45 and 55 per cent of the season's growth by June 15 and gave a better carry-over into the hot summer period. Total yields were almost similar for the two cutting treatments with the plots cut at 4- to 6-inch heights having a slight advantage.

Title: Test of Grasses and Legumes for Poultry Ranges.

Leaders: Gilbert H. Ahlgren and C. S. Platt.

This test was described in the 1942 report, Page 84. The 16 grasses and seven legumes were under experimental range conditions in 1943 with 50 pullets being maintained in each pen. Preliminary results indicate some differences between nutritive value and palatability of the grasses and marked indications that the pullets preferred the grasses to the legumes. Results are based on gain in weight by the pullets and on observations noted during the season.

Title: Species of Grasses for Hog Pasturage.

Leaders: Gilbert H. Ahlgren and George Van Der Noot.

Twelve grasses seeded in 1/12-acre plots in September 1942 (1942 Annual Report, Page 85) were used for pasturing hogs in 1943. These species included red fescue, alta fescue, bromegrass, orchard grass, timothy, Canadian wild rye, domestic and perennial ryegrass, meadow foxtail, reed canary grass, redtop, and Kentucky bluegrass. All species excepting Canadian wild rye appeared to be relished by hogs when young. The ryegrasses and meadow foxtail were not eaten as readily when they became older but it was not possible to tell whether or not this was due to their early maturity compared to the other grasses or if some other factor was involved.

Title: Comparison of Orchard Grass Strains and of Bromegrass Strains for Pasture Purposes.

Leaders: Gilbert H. Ahlgren, Carl B. Bender, and Carlton S. Garrison.

Two paddocks each four acres in size are being used in this study. Each paddock was divided into three areas of 1-1/3 acres each. Three strains of orchard grass, Brage, S-26, and commercial, and three strains of bromegrass, Achenbach, 2683-1, and commercial, were planted in early September 1942, one strain to each 1-1/3 acre area. An over-all seeding of Ladino clover was made in the orchard grass paddock and alfalfa in the bromegrass paddock. A good stand was obtained in all cases.

During the winter of 1942-43 the Brage and S-26 orchard grass winterkilled almost 75 per cent. The commercial orchard grass came through with little or no winterkilling as did all the bromegrass strains. Achenbach and commercial bromegrass appear much more vigorous than does the somewhat procumbent growing 2683-1 strain of bromegrass.

A similar test is being conducted in Warren County, New Jersey.

Title: Improved Grass Species and Strains.

Leader: Gilbert H. Ahlgren.

In September 1942 selections of outstanding grasses from the grass and legume introduction nursery were planted in replicated field plots 78 feet long and five feet wide. These strains were the most outstanding from a group of about 200 tested for three years previously in row plots. No yield data were collected in 1943 but general observational information was taken. Dry matter production studies will begin in 1944. All grass strains are being utilized as if for hay production.

Title: Seeding Depths for Various Grass Seeds.

Leaders: Gilbert H. Ahlgren and Irving Burack.

Seed of 12 grass species were planted in a sassafras loam soil in flats in the greenhouse at depths of 1/4, 1/2, one, two, and three inches. The species tested were perennial ryegrass, redtop, Kentucky bluegrass, bromegrass, orchard grass, creeping bentgrass, timothy, red fescue, alta fescue, and meadow foxtail. The purpose was to determine the most favorable seeding depth for the seeds of each species.

All seeds produced good stands at 1/4 inch. Seedling emergence of Kentucky bluegrass, redtop, and creeping bentgrass was somewhat restricted at 1/2-inch depths, strongly restricted at a 1-inch depth and there was no seedling emergence of these species seeds at two or three inches. Orchard grass, timothy, and meadow foxtail were restricted slightly at one inch, strongly at two inches, with no emergence at three inches. A smaller percentage of seedlings of perennial ryegrass and of alta fescue emerged from a 3-inch depth.

Title: Response of 5 Bromegrass Strains to Several Cutting Treatments.

Leaders: Gilbert H. Ahlgren and Maynard Klorman.

Five strains of bromegrass are under test in the greenhouse. The purpose is to test for differential response to various cutting treatments. Four heights of plant growth will be used, namely, three inches, six inches, 12 inches, and mature before clipping back. Results will be measured by dry matter accumulation. No data have been obtained as yet.

Title: Survey of Multiple-purpose Sods.

Leader: Herbert R. Cox.

A study of pasture management practices as favored by some of the leading dairymen in New Jersey, indicates that many of our farmers are becoming increasingly critical of bluegrass for pasture. There is a tendency to seed down to semi-permanent sod with such grasses as orchard grass, timothy, and smooth bromegrass, and with such legumes as Ladino clover, red and alsike clover, and alfalfa. Our dairymen are finding these sods highly useful for mowing for hay, for grass silage, and for pasture purposes. Such sods are more useful than bluegrass, in that they are more productive especially during the summer months and that they can be used for several purposes. The reaction of farmers toward the multiple-purpose sod mixtures is exceedingly favorable.

Title: The Utilization of Korean Lespedeza for Summer Pasture.

Leader: Herbert R. Cox.

Korean lespedeza has been grown on several farms in this state for a number of years. It holds some promise as a summer pasture crop where conditions are favorable, especially when it is grown with a spring grain crop. Once seeded in the spring and given favorable opportunity, Korean lespedeza should maintain itself by regular self-seeding each fall.

Cooperative tests with five farmers in Central New Jersey were started in the spring of 1943. Good stands of lespedeza were secured in all five tests and seed was matured in each case last fall. Oats will be sown this spring without plowing. The seedbed will be prepared by harrowing. If successful, this system would supply good pasturage throughout the summer season at a minimum of labor and expense.

Korean lespedeza is also being investigated for use on permanent pastures where the soils are poor and other vegetation sparse.

Title: Pasture Renovation Studies.

Leader: Herbert R. Cox.

Six pasture renovation tests were started in 1942 on poor pasture sods in Hunterdon, Somerset, and Sussex Counties in North Jersey. The soil was limed and fertilized and then thoroughly disked to prepare a suitable seedbed in the early spring. An adapted mixture of clover seed was then sown. The results secured last

year were not too favorable to this method. A good stand of the adapted clovers was secured in one test; fair stands in two tests; and poor stands in three tests. It is concluded that better stands were not secured because the weather was exceedingly dry for several weeks following planting in the spring of 1942. It appears that the success of this method depends largely upon a favorable moisture supply at the time of seeding and seedling establishment. This study is continuing.

Title: Drilling Lime, Fertilizer and Clover Seed into Poor Land Pastures.

Leader: Herbert R. Cox.

Clovers have been successfully established on small plots for the past several years by the following method: A narrow slit is opened in the sod about an inch deep or just deep enough to get through the sod. Lime and fertilizer in small amounts are distributed in the slit and finally legume seeds are scattered on top of the lime and fertilizer. Good stands have nearly always been secured in these seeded rows. This method has been particularly successful in establishing birdsfoot trefoil. We are now working with several commercial implement manufacturers to develop a machine which will duplicate this hand operation on a field scale.

Title: Morphological Response of Timothy to Applications of Nitrogen Fertilizers.

Leader: John C. Anderson.

A two year old timothy sod was given the following fertilizer applications per acre in April: 10 tons of manure, 30 pounds of elemental nitrogen, and 60 pounds of elemental nitrogen in the form of sodium nitrate. Additional applications of either 30 or 60 pounds of nitrogen were made at early bloom when the first series of plots were harvested. The second and third series were harvested 10 and 20 days afterward, respectively. Plant samples taken were divided into corms, stems, green leaves (and sheaths), dead leaves, and heads.

Conclusions. 1. Regardless of the April treatment, applications of nitrogen fertilizer to timothy sod at the early bloom stage of maturity did not stimulate any marked additional accumulation of dry matter in the 20-day period that followed.

2. The 60-pound rate of nitrogen application in April promoted more steminess, caused severe lodging, and a lower proportion of green leaves in the hay than could be attributed to the 30-pound rate.

3. The increase in yields of dry matter was about the same for the 30- as for the 60-pound per acre rate of nitrogen application.

Title: Strain Studies with Zig-zag Clover.

Leaders: John C. Anderson and Gilbert H. Ahlgren

A nursery containing 160 zig-zag clover plants is under observation for individual plants producing viable seed. Seedheads were collected from each plant and rubbed out to obtain the seed. Plants which developed well and appeared most vigorous in the field were noted and seed from these plants have been planted in flats in the greenhouse. The seedlings will be placed in the field in the spring of 1944.

A greenhouse study is being conducted to determine the most favorable pH for the optimum growth of zig-zag clover. Determination of dry matter production will be made. Some seed studies are also contemplated. Two clones of different characteristics are being used, both having made vigorous growth in the field. One clone has a moderate number of stems with large leaves and the other has many fine stems and small leaves.

Title: Comparison of Pasture Sods and Management Practices.

Leader: C. S. Garrison.

During the grazing period in 1942 and 1943, growth data on six pastures in Burlington County (South Jersey) were obtained. These pastures were divided in three groups of two each, being treated as follows:

1. Two pastures of Ladino clover-timothy mixture, receiving each year 500 pounds per acre of a 5-10-10 or 4-10-10 fertilizer. The land was limed before seeding the mixture and the pH has been above six during the time the clipping data were obtained. Rotational grazing was practiced.

2. Two permanent pastures predominatly Kentucky bluegrass-white clover, receiving heavy applications of fertilizer each spring and lime when necessary. Rotational grazing was practiced.

3. Two permanent pastures predominantly Canada and Kentucky bluegrass, sedges, annual weeds, and some white clover. Have received no fertilizer or lime for a long period of time. Continuous grazing during the entire season.

Two cages (2 ft. by 6 ft.) were placed on each of the six pastures. Clippings were made when the grasses and legumes were eight inches to 10 inches tall. The Ladino clover pastures were clipped most frequently, the well-managed bluegrass-white clover mixtures next, and the unimproved pastures the least.

The data obtained for the 2-year period is given in Table 23.

Table 23. Yields of certain grass-legume mixtures.

	Pounds per acre (dry weight)		
	1942	1943*	2-yr. average
Ladino-timothy	7078	5230	6154
Improved Kentucky bluegrass-white clover	4032	2840	3436
Unimproved bluegrass-white clover	2580	1670	2125

* Dry period during July and August.

The yield in 1943 was much lower than 1942 due to the very dry period experienced during July and August. Even during this adverse growing period the Ladino clover pastures were harvested more frequently than the others. However, the Ladino clover fields were on slightly lower soil.

Title: Comparative Value of Various Grasses and Legumes for Poultry Range on Light Soils.

Leader: C. S. Garrison.

In August 1942, two poultry ranges were seeded on light soils, using a variety of different legumes and grasses. In each demonstration the legumes were planted in separate plots and the grasses were seeded in the opposite direction. These demonstrations were observed during the year for growth made by the various forage species on light soils.

While no yield data were obtained, the Ladino clover-bromegrass mixture appeared to give the best performance. In the southern part of New Jersey there was a prolonged drought period during July and August. Timothy was most retarded in growth by the

lack of moisture, followed by ryegrass, tall fescue, and orchard grass, and the least affected was bromegrass. It is very interesting to note that the Ladino clover was green and made some growth during the entire dry period. The other legumes included common white clover, alsike clover, red clover, and sainfoin.

The two poultry ranges were well fertilized and limed. A good seedbed was prepared and all the grasses and legumes got off to a good start. Where ample fertilization is present, the Ladino clover is more likely to survive. Undoubtedly in many cases, failure of Ladino clover on the lighter soils is due to improper fertilization.

Title: Belle Ellen Pasture Experiment.

Leader: C. B. Bender.

The Belle Ellen pasture area, comprising 45 acres divided into 11 pastures under rotation management, carried 40 head of milking Holsteins for 48 days and 41 head of milking Guernseys for 123.5 days. Because of severe summer drought, these pastures produced only 1307 pounds of four per cent fat corrected milk per acre, which was one-half as much as produced in 1942 (1942 Annual Report, Page 87).

Title: Fertility Levels on Dairy Farms.

Leader: C. B. Bender and Firman E. Bear.

A complete description and method of procedure of this project is contained in the 1941 report, Page 83 of the Pasture Research Laboratory. A cold, wet spring retarded growth, delaying the initial grazing date until May 13. This period was followed almost immediately by a drought which continued all summer.

The average dry-matter yield per acre of the 20 bluegrass-white clover plots was 2443 pounds and the 16 Ladino clover-grass plots yielded 3591 pounds per acre. The returns from the use of potash on the Ladino pasture B-14 were very outstanding. In this trial, the plot receiving no potash yielded 1474 pounds of dry matter per acre.

Plot receiving 50 pounds K_2O yielded 3572 pounds of dry matter per acre.

Plot receiving 100 pounds K_2O yielded 4022 pounds of dry matter per acre.

Plot receiving 200 pounds K_2O yielded 4823 pounds of dry matter per acre.

This is the third successive year for these annual applications in this experiment.

Title: Pasture Fertilization in Relation to Carrying Capacity. (Vyker Farm).

Leader: C. B. Bender.

The Vyker Farm area, comprising 51 acres grazed by growing dairy heifers, produced an average gain of 132 pounds live weight per animal at a cost of .031 cents per pound gain. In terms of total digestible nutrients according to Morrison, the area yielded an average of 1532 pounds per acre, which is equivalent to 139.8 cow days per acre for a 1000-pound cow.

Title: New Pasture Species.

Leader: C. B. Bender.

Of the new pasture type grasses, dairy heifers show a preference for orchard grass S-26, Brage orchard grass, tall oat grass, meadow foxtail, creeping bromegrass and reed canary grass.

Orchard grass S-26 and Brage orchard grass, seeded in pure stands, have formed a close sward and are resisting invasion of volunteer species at the end of the third year.

Reed canary grass produced one ton per acre of dry hay at the second cutting which was twice the yield of second cutting alfalfa.

A new pasture seeding of Ladino clover and Milton timothy produced an average of 4500 pounds of dry matter per acre.

Ladino clover, seeded in a dense Kentucky bluegrass sod in April 1940, followed by a five ton per acre manure application, shows a count of 41 per cent Ladino clover in the fall of 1943.

NEW YORK (CORNELL) AGRICULTURAL EXPERIMENT STATION

Title: Breeding Timothy for Hay and Pasture.

Leaders: C. H. Myers and W. I. Fisher.

The work on this project for the past year consisted chiefly of maintaining seed stocks of the two strains of timothy, No. 1777 and No. 4059, which have been developed as a result of the timothy improvement project. These two strains differ especially from the standpoint of earliness, and there is some difference in rust reaction. No. 1777 is an earlier strain and is recommended for the northeastern part of New York State, especially in seasons

when rust is very prevalent. When rust is not too serious, No. 4059 will be about equal to No. 1777 in yield, but in years of heavy rust development it does not do so well.

In order to continue the production of pure seed of these varieties, a new plot of each was planted in the fall of 1943. So far as multiplication of the seed is concerned, the increasing of No. 4059 has been left largely to Doctor H. B. Sprague, of the New Jersey Agricultural Experiment Station. In 1942, Mr. N. E. Flitters, of East Aurora, New York, obtained pure seed of both strains with the intention of producing commercial lots of seed of these improved varieties.

Title: Breeding Alfalfa for Winter Hardiness and Yield for Hay or Pasture.

Leaders: C. H. Myers and W. I. Fisher.

No new investigations were undertaken under this project in 1943. Comparison of a number of different strains of the F_4 and F_5 progenies from the cross of Medicago sativa and Medicago falcata, conducted with seedings made in 1938 and 1940, indicated that a few strains were outstanding in their performance. These appeared to be similar in general growth and behavior, and it was decided to combine the seed of these seven strains in a composite lot for the purpose of multiplication. Owing to the very unfavorable season and the shortage of labor, this synthetic mixture was not sown in 1943 and the seed is held over for sowing in 1944.

Title: Pasture Seeding Mixture Experiment (Mount Pleasant Farm).

Leader: R. B. Musgrave.

Yield and chemical composition were determined as described in the 1941 report, Page 96. The three clippings made in 1943 yielded only one-half to two-thirds as much dry matter as was obtained in 1942. All seven seeding mixtures yielded the same in 1943. Mixtures having a high percentage of clover in 1942 had an equally high amount in 1943. This fact coupled with the yield information indicates that conditions were relatively more unfavorable for the growth of legumes than for grasses in 1943.

Chemical data for the 1942 clippings indicate the usual relationship of relatively high nitrogen and calcium content where the legume content is high. Phosphorus tended to be lowest in those mixtures which were high in nitrogen and calcium. Potash content differed for the various mixtures but did not appear to bear any relation to botanical composition.

Title: The Value of Birdsfoot Trefoil as a Pasture Legume in New York.

Leader: H. A. MacDonald.

The work of this project, as previously outlined (1942 Annual Report, Page 92), was continued. Certain strains of birdsfoot trefoil were found to be most productive under a system of rotational grazing where close grazing was avoided. On lower fertility soil, the dwarf form of birdsfoot trefoil made fair growth and withstood close grazing. Under suitable management, birdsfoot trefoil compared favorably with the other legumes under study for pasture use.

Title: The Study of Plant Associations for Pasture Purposes.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

Considerable restriction had to be made in the carrying out of this project during 1943. Certain of the seedlings were carried on a maintenance basis while others were continued under study. Yield of dry matter and records of the botanical composition of such yields were obtained on the 1939, 1940, and 1941 seedings. Considerable change in the persistence and production of the various seed species was noted. Many of the legume strains under study were severely injured during the winter of 1942-43. The more upright growing grasses showed their inability to persist in a closely grazed sward. The results of this investigation should be summarized in the near future.

Title: Pasture Survey of New York.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

The work of this project was discontinued for the season of 1943. It is to be continued when conditions permit.

Title: The Influence of Grazing Management on the Yield, Botanical Composition, and Chemical Composition of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

This project was continued on a reduced basis during 1943. In general, the highest dry matter yields in 1943 were produced from those seedlings having adequate root reserves in the fall of 1942. Late fall grazing, after October 1, resulted in a sharp decline in pasture yield during the following year. Very frequent close

grazing or plant defoliation resulted in an increase in the amount of wild white clover but a marked decline in dry matter yield. Insufficient grazing resulted in a reduction in the amount of clover present and a lowering of the yield except where such infrequent grazing removed the greater part of the vegetative growth present at that time. The long-time effect of the various management practices studied in this trial is now becoming apparent. Many of the treatments which initially gave high yields are now low in production while the less drastic treatments, which allowed for recovery and root storage, are being maintained at a relatively high yield level.

Title: The Influence of the Grazing Habit of Cattle on the Composition, Consumption, and Utilization of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

This project was inactive in 1943. It is planned to continue these studies in the near future.

Title: Poultry Pastures.

Leaders: G. F. Heuser and L. C. Norris in cooperation with D. B. Johnstone-Wallace and J. K. Wilson.

On July 3, 1943, four lots of S.C.W.L. pullets, three months old, were placed on pasture and grown for three months. Three lots were on Ladino clover pasture and one lot on a poor pasture consisting mostly of Kentucky bluegrass, wild white clover and weeds. There was sufficient rainfall during the summer to keep all the pastures from drying up.

There was no significant difference between the lot receiving a regular growing ration ad libitum on the Ladino clover pasture as compared with the same ration and method of management on the regular pasture.

One lot on Ladino clover pasture was restricted in feed by giving them mash only in the morning in amounts sufficient to last about two hours. Grain was fed in the afternoon in amounts that the birds ate in 10 to 15 minutes. No mash was fed on Wednesdays and no feed at all on Sundays. The restricted lot did not gain as well as the lot which received feed ad libitum. Their average weight at six months of age was 3.17 pounds as compared with 3.41 pounds for the control. However, they ate 3.09 pounds less feed per bird which was 22.8 per cent less than the control birds. The control lot came into production nearly one month earlier than the restricted lot and produced at the rate of 12 per cent for the month of September as compared with three per cent for the restricted lot.

One lot of pullets on Ladino clover pasture was given only grain, both whole and ground, with the feed available at all times. These birds gained very little during the first month. In fact a large number of the individuals lost weight. However, after that time they made good gains and at six months of age were slightly heavier than the restricted lot with an average weight of 3.23 pounds but not as heavy as the birds on the regular ration. Their feed consumption per bird was nearly the same as the other lots with feed always available. They came into production a little earlier than the restricted lot, laid more eggs during September than the restricted lot, but not as many as the control lot.

Title: The Improvement of Pastures and Forage Crops in Northern New York.

Leaders: L. S. Fink and R. Bradfield.

Object. To determine the full potentialities of grassland vegetation as a source of feed for dairy animals. Every attempt, with progress governed strictly by individual farmer initiative, is being made to:

1. Markedly increase the amount of pasture and roughage-made milk on several dairy farms. (Table 24 indicates the extent to which the amount of pasture-made milk was increased this past season on one farm; this herd, during previous seasons, having been fed approximately one pound of grain to four pounds of milk produced.)

2. Determine the yield of milk (or equivalent) per acre from various kinds of pasture and forage crops variously managed.

Table 24. The milk grain ratio during periods indicated. Farm B.

1943 Period	Source of roughage or pasture	Milk (4 per cent) grain ratio
5/1-5/19	Barn roughage	3.08
5/20-5/27	Barn roughage plus native pasture	3.46
5/28-5/31	Native pasture	5.08
6/1-6/7	" "	6.81
6/8-6/14	" "	7.60
6/15-6/21	" "	7.30
6/22-6/28	" "	6.54
6/29-6/30	" "	6.12
7/1-7/7	" "	5.32
7/8-7/16	" "	4.99
7/17-7/25	Oats (nitrogen top-dressed)	12.06
7/26-7/31	Native pasture	5.51
8/1-8/10	Alfalfa-Ladino clover aftermath	7.90
8/11-8/17	" " " "	7.75
8/18-8/24	" " " "	8.30
8/25-8/31	" " " "	7.51
9/1-9/20	" " " "	4.73

All investigations are conducted on dairy farms. Small plot (pilot) trials, covering special problems, are established on each farm, and these plots are subject to management practices common to the particular farm, except for the items under control in the trial.

This project was started in the spring of 1943, and subsequent reports will summarize results in full.

Title: Biology and Control of the European chafer *Amphimallon majalis* Razoum.

Leaders: H. H. Schwardt and W. H. Whitcomb.

Further observations on this recently introduced pest indicate that it is a pasture as well as a lawn pest. More than fifty acres of well-kept pasture in Wayne County have been destroyed and much more has been injured. The potentiality of this species as a pasture pest exceeds that of the native white grubs since it has a 1-year cycle and injury, therefore, occurs every year.

The 1-year cycle has been established by rearing about 100 specimens from egg to adult, and by seasonal history observations. The adults are crepuscular and fly from early June until late July. The first eggs are found about June 20, first larvae about July 6, and first pupae about May 20 of the year following deposition of the eggs.

Title: White Grubs and Other Forage Crop Insects.

Leaders: H. H. Schwardt and R. F. Pendleton.

Heretofore most commercial injury from white grubs in New York has been caused by the "C" brood, adults of which were on the wing in 1937, 1940, and 1943 with years of larval injury following or expected to follow in 1938, 1941, and 1944. In 1942 an extensive flight of "B" brood beetles occurred in parts of Jefferson, St. Lawrence, Essex, and Otsego Counties. This flight was of such magnitude as to indicate that the brood will persist for some years. This does not represent a shift in the relative importance of broods in New York since the older "C" brood flew in large numbers in 1943 and increased in intensity in some areas.

An unusually high percentage of parasitism occurred in two areas in 1943. In central and western New York dipterous parasites destroyed up to 60 per cent of the adults in small areas. In St. Lawrence County the newly discovered "B" brood larvae were heavily attacked by the entomophagous fungus *Cordyceps* sp.

PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION

Title: Testing and Breeding Grasses for Pasture and Other Uses.

Leaders: J. K. Thornton, H. W. Higbee, C. C. Vernham, F. V. Grau, S. I. Bechdel, P. D. Jones, P. H. Margolf, and F. L. Bentley.

The emphasis in this project (1942 Annual Report, Page 98) is being shifted from fine turf to a pasture program, which involves formal cooperation with the Departments of Dairy Husbandry, Poultry Husbandry, Animal Husbandry, and informal cooperation with the Pasture Research Laboratory. While the fine turf program of testing strains of bentgrass, bluegrass, and fescue for lawns and golf courses was continued, these plots received only essential attention and minimum care during the last year.

Under the conditions as outlined, three of the creeping bentgrass selections have stood out surprisingly well, namely, 11 (34) 2, 12 (38) 1, and 10 (37) 4. These selections escaped the Dollar Spot epidemic (one of the severest in several years), almost entirely and maintained satisfactory growth through the season.

During the season, Thiosan, hydrated lime and untreated plots were used to determine (1) the effect of hydrated lime at 10 pounds per 1,000 square feet on the incidence of clover on our clay loam soils and (2) the effect on control of Copper Spot (Gloeocercospora sp.). An over-all infection of Dollar Spot obscured the results of disease control, but little increase in clover population on the heavily limed plot resulted. Thiosan at six ounces per 1,000 square feet applied every two weeks was not too effective in controlling Dollar Spot under our conditions. Hydrated lime at the above rate applied at the same time had no effect on Dollar Spot, as was expected, but did appear promising against Copper Spot.

Repeated attempts to induce Copper Spot by artificial inoculation failed, in spite of the fact that the disease was quite severe in uninoculated areas.

In the pasture program new plots were seeded in cooperation with the Lairy Department on some poor, dry, steep slopes. Several of the grasses and legumes became well established. Records will be obtained on persistence of species and on comparative yields under grazing management during the summer of 1944.

Plans have been made and will be carried out in 1944 for pasture seedings and management studies, using several of the large-type grasses in combination with Ladino clover and birdsfoot trefoil in dairy pastures.

Work has been started on pasture ranges for turkeys in cooperation with the Poultry Husbandry Department. Orchard grass, tall fescue, bromegrass, tall oat grass, and reed canary grass are being used in combination with Ladino clover and birdsfoot trefoil on these ranges. Records will be taken on yields, persistence and preference by birds.

Birdsfoot trefoil pastures, started in November 1941, have become well established on extremely low fertility soil located on dry slopes. When seeded, these areas received a ton of lime and 250 pounds of 20 per cent superphosphate per acre. The areas were protected from grazing until late last summer. Formerly some of these areas were not producing even good poverty grass. Because of the lack of moisture, it is unlikely that white clover could persist on some of the locations.

Title: Pasture Management Studies at Montrose, Pennsylvania.

Leaders: For The Pennsylvania Agricultural Experiment Station - C. F. Noll and S. I. Bechdel.
For the Division of Forage Crops and Liseases, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture - M. A. Hein and S. R. Skaggs.

Yields from all the experimental pastures were below the 1942 figures (1942 Annual Report, Pages 100 and 101). This may be explained by the less favorable distribution of rainfall during the growing season.

Following are some figures which show the approximate relative production of the pastures for the season of 1943.

Permanent Pastures

Managed grazing (grass kept at a height of two to four inches during the grazing season)	100%
Continuously grazed with 1-1/2 acres per cow (600 pounds of silage per acre was fed during late summer)	91
Mowed for grass silage and grazed thereafter (2667 pounds of grass silage per acre was harvested in June before the pasture was grazed)	30
Mowed for grass silage in 1942, grazed during 1943	111

Pastures in Crop Rotation
(Largely Ladino clover, orchard grass, meadow fescue and timothy)

Grazed for entire season	152
Cut for hay, aftermath grazed*	75

* A yield of 2933 pounds of hay per acre was harvested from this pasture before June 22. Grazing was stopped on September 1.

Grass-legume combinations cut for hay and aftermath were harvested for the second year. Highest yields were obtained from the plots containing timothy and Ladino clover. Stands of alfalfa were seriously depleted during the previous winter and spring. While aftermath yields from the orchard grass plots made up a larger percentage of the total yield than in the case of the timothy plots, the total yields of the timothy plots were greater. While most of the plots yielded less than during the previous season, the birdsfoot trefoil made a higher yield. The stand of trefoil had improved until it made up a considerable part of the first cutting and considerably more than half of the second cutting. Nearly one-third of the season's yield from this plot was harvested in the second cutting.

Data on yields and stands were taken on the uniform nursery grass strain tests. In nearly every case the improved strains outyielded the ordinary commercial seedings. However, the increases were quite small in most cases. An increase of the Brage strain of orchard grass, O-2, a Cornell selection of timothy, T-3, meadow fescue, M.F.-3, alta fescue, and a Nebraska selection of smooth bromegrass, B-4, were the highest yielding strains in these tests.

Yields from the timothy and meadow fescue strains were close to two tons per acre while the bromegrass strains yielded about 1-3/4 tons and the orchard grasses all yielded less than 1-1/2 tons of hay per acre.

Ladino clover stands were better when grown with bromegrass than when grown with any of the other grasses in the test.

Title: Fermentation of Alfalfa Silage.

Leaders: R. W. Stone, S. I. Bechdel, and P. S. Williams.

During the summer of 1943, eleven alfalfa silages were put up in small experimental silos, and the fermentation was followed by microbiological and chemical analyses. The main purpose of the study was to determine the effect of various degrees of wilting on the alfalfa, particularly to very low moisture content as previous studies have shown (1942 Annual Report, Page 101) that good results are obtained by wilting to about 65 per cent moisture.

In June 1943, four silos were filled with a fair quality alfalfa, first cutting. In each case the alfalfa was wilted from one to three hours before raking. The moisture content of Silages 1 and 2 was still further lowered by the addition of 200 and 100 pounds, respectively, of dry hay. To Silages 3 and 4 were added ground wheat and ground corn. Each silage fermented satisfactorily and appears to be of good quality. It is noteworthy that Silages 3 and 4 which were not wilted as much as 1 and 2 have a substantially

lower amount of reducing sugar on a dry-weight basis. Due to their higher moisture content and the presence of a quantity of available carbohydrate from the grain added, the fermentation went faster than the silages containing dry hay. Silages 3 and 4 were fed at 40 to 50 days, had satisfactory odor and appearance, and were palatable to the stock. Silage 1 has not been opened at this time. Silage 2 has been fed during January and likewise seems to be of good quality.

A second group of silages was put up early in August 1943 from a fair quality second cutting of alfalfa. Silage 5 alfalfa, cut in the evening and wilted the next morning, showed somewhat higher amounts of reducing sugar for the first month of storage than Silage 6 which was cut in the morning and allowed to wilt the same day. At the end of two months, more of the sugar of Silage 5 has been converted to acid as indicated by its lower pH. Silages 7 and 8, put up with Dem-O-Lac and beet pulp, respectively, both fermented satisfactorily. The higher sugar content of Silage 8 was due to the fact that although cut in the morning, it was not filled until the afternoon. As the day was quite warm, the forage was wilted to a figure comparable to Silages 5 and 6. None of these silos has been opened, but samples showed good odor and appearance.

A third group of silages was put up on September 27, 1943, in order to ascertain the effect of a high degree of wilt. Silages 3A and 3B, comparing evening and morning cut, reflected a large difference in sugar originally, but this did not hold on later samples. Silage 4T is about the appearance and texture of alfalfa hay, but has a faint odor suggestive of slight fermentation. All of these silages are fermenting quite slowly and are still unopened.

In all eleven silages, lactic acid bacteria are found to be predominant. However, in the dryer forages, particularly 3A, 4B, and 4T, the bacterial counts are low and a mixed flora occurs. Yeasts are fairly common and some spore forming rods are found.

A summary of the data collected in 1943 is shown in Table 25.

Title: A Study of Several Annual Crops for Silage Purposes and as Preservatives when Ensiled.

Leaders: C. O. Cromer, S. I. Bechdel and A. L. Haskins.

The objects of this experiment were to test the relative merits of Sudan grass, corn, two grain sorghums and two well-known sweet sorghums as preservatives for legumes when ensiled. A second purpose in conducting the experiment was to determine the yielding ability of the various crops as well as their general adaptability. (See Table 26.)

The crops were all planted in rows thirty inches wide for the purpose of cultivation, and for convenience in harvesting with a corn binder. Samples were taken of each of the crops grown as they were ensiled and the percentages of total reducible sugars determined.

Table 25. Summary of data on silages put up in 1943.

Time put up	Silage No.	Description	Per cent H_2O		Per cent sugar as glucose, dry weight		pH	
			0 day	60 days	0 day	60 days	0 day	60 days
First cutting	1	200 lb. dry hay	51	51	5.2	4.8	6.25	4.74
June 16	2	100 lb. dry hay	57	57	4.4	3.5	6.25	4.42
								45 days
	3	200 lb. ground wheat	64	67	2.7	1.2	6.40	4.39
	4	150 lb. ground corn	64	70	2.8	1.6	6.35	4.40
								60 days
Second cutting	5	Wilted--evening cut	60	50	7.6	6.3	5.70	4.45
August 3	6	Wilted--morning cut	50	48	6.8	7.0	5.70	4.78
	7	100 lb. Dem-O-Lac	65	68	3.1	0.6	5.82	4.23
	8	Wilted--100 lb. beet pulp	50	51	6.6	2.1	5.68	4.12
				30 days		30 days		30 days
Third cutting	3A	High wilt--evening cut	45	43	12.1	8.3	5.60	5.16
September 21	4B	High wilt--morning cut	40	40	9.1	9.0	5.60	5.39
	4T	Very high wilt	30	27	9.5	9.6	5.62	5.52

Due to the fact that Sudan grass became badly rusted before ensiling, the total percentage of reducing sugars is much lower than might have been indicated had the crop not been rusted at all. The soybeans were rather immature. The pods were formed, but the seeds were not over fifty per cent developed. The sorghums were not as fully matured as they should have been for silage purposes. The majority of the seeds were still in the milk or early dough stage.

As might be expected the presence of the soybeans in the mixture reduced the yields very materially in all cases.

Table 26. Yields per acre of silage; per cent of total reducing sugars; and analysis of the mixtures. Average 1942-43.

Crops used	Average yields tons per acre		Per cent total reducing sugars in the crops grown		Per cent of each crop in mixture	
	Alone tons	Soybeans tons	Alone	With soybeans	Grass crop	Soybeans
Sudan grass	8.27	8.57	.82	1.09	79.0	14.8
Corn	10.73	9.69*	5.02	4.49	89.0*	11.0*
Hegari	11.50	8.88	5.45	3.84	70.4	23.8
Norkan	14.33	9.79	4.47	3.65	69.0	24.2
Early amber sorgo	15.50	12.13	5.93	4.98	85.7	13.0
Early sumac sorgo	18.58	11.82	6.22	4.45	64.7	31.0
Soybeans	4.37	-	1.78	-	-	-

* Figures with asterisk are for 1943 only.

Title: Commercial Grass Seed Production.

Leaders: J. K. Thornton, H. W. Higbee, F. V. Grau, A. W. Clyde, E. J. Anderson, C. C. Vernham, and M. Wood

During the last year, the Department of Zoology and Entomology became a cooperator on this project. In addition, the Pasture Research Laboratory cooperated informally.

Commercial grass and legume seed production encouraged by this program is growing steadily. Approximately 300 acres in row plantings of red fescue and the Penn State blend of Chewings fescue will be harvested for seed production during the summer of 1944. In addition, about 35 acres of orchard grass, mostly improved strains, will be harvested.

Performance records were obtained from a USDA cooperative uniform grass nursery in which orchard grass, bromegrass, meadow fescue, timothy, redtop, reed canary grass, tall oat grass, crested wheatgrass, Kentucky bluegrass and red fescue were harvested for forage

when grown alone, with birdsfoot trefoil, with Ladino clover and with alfalfa. Seed production was obtained for each grass selection from both row and broadcast seedings. During this first crop season, the forage yields were highest with alfalfa, second highest with Ladino clover, and about equal on the plots where seeded alone or with birdsfoot trefoil. In most cases, however, the birdsfoot trefoil was poorly established, Bromegrass, particularly that originating in Iowa and Nebraska, gave higher yields than other grasses. Tall oat grass also yielded very well. Other productive, leafy and desirable grasses were orchard grass, timothy, and reed canary grass. Yields of seed were as high from broadcast plots as from row plots, or higher.

Management studies in red clover seed production were conducted both at the Experiment Station, and in several of the red clover seed producing areas of the state. These studies were concerned with the effect of high and low clipping at different stages of maturity of the first crop, on seed production from the second crop, and the effect of boron treatments on seed production. In cooperation with the Department of Zoology and Entomology, the effect of honeybees on seed set in red clover was studied. Results are not ready for publication on any of the red clover work at the present time.

Burning the seed rows of Chewings fescue in early spring for Silver Top disease control was continued as in the previous year. Use of a flame thrower produced damage to seed production in some instances. The time and degree of burning are important factors to regulate. A 6-year old field, which had produced 100 per cent Silver Top during the previous two years, was burned severely in the spring of 1943. A moderate crop of good seed was produced in July, and the percentage of Silver Top was negligible. It is believed this field can be brought back to full seed production in 1944. Part of this field was burned in December 1943, another part will be burned in March 1944, and the remainder will be left unburned.

Because the results had been good with Chewings fescue, it was decided last March to burn plots in an orchard grass seed production area. Results were rather striking. Six plots were burned and alternate plots were left unburned. Each plot consisted of four rows, each 20 feet long and three feet apart. New growth started earliest on the burned plots. In checking the plots about blossoming time, it was noticed that leaf spot was quite severe on the unburned areas and very slight on the burned areas. There seemed to be more seed heads and more uniform maturity of seed heads on the burned plots. This was confirmed at harvest time for seed yields were consistently higher on the burned plots when compared to those plots not burned. The burned plots averaged 175 pounds and the unburned plots averaged 120 pounds of seed per acre.

Seed yields were harvested from bromegrass, orchard grass, red fescue, and crested wheatgrass which had been seeded in replicated row plots at rates from two pounds to ten pounds per acre. There was a good stand of grass from each seeding rate, and no significant differences in seed yield resulted from the highest to the lowest rate of seeding.

Seedings of a large number of grasses and legumes were made at the last cultivation of corn to determine their value as cover crops and for seed production.

Preliminary investigations on seed cleaning and drying indicate that it may be practicable to make broadcast seedings, which can be harvested by a swathing machine leaving the seed heads on high stubble. By this method the seed can be cut before it starts shattering. Rain is shed or passes through the seed heads without discoloring the seed. When dry enough, the combine with a pickup attachment can thresh the seed without picking up stones, and the seed should be dry enough to be placed in storage without much extra handling.

Observations on combine efficiency were made last summer. It was learned that most combines cannot be thoroughly cleaned when moved from one type of seed to another, and hence combines are a constant source of contamination. This is a serious problem which must be settled if custom combines are to be used in harvesting elite stocks of seed. It was learned, too, that many combines may lose a large percentage of seed because of improper adjustment of cylinder speeds and air blast.

Attempts are being made to harvest Ladino clover seed more efficiently. The Department of Agricultural Engineering is working on a harvester for this purpose.

VERMONT AGRICULTURAL EXPERIMENT STATION

Title: Relative Value of TVA Phosphates on Pasture and Meadow Land.

Leader: A. R. Midgley.

Both greenhouse and field plot studies justify the following conclusions concerning use of TVA phosphate in Vermont:

1. Calcium metaphosphate seems to be as efficient as ordinary superphosphate for hay and pasture lands when compared over several years. Since calcium metaphosphate is less soluble than superphosphate, it is usually less responsive the first year when used as a top-dressing especially during a dry year. Over a 3-year period hay and pasture yields have been similar when the materials were used on an equivalent P_2O_5 basis.

2. Most Vermont soils seem to contain or at least receive sufficient sulphur from air and rainfall so that gypsum as a source of sulphur is unnecessary. However, it seems likely that some northern Vermont farms located at a distance from cities and manufacturing plants may give some plant response to added sulphur. Superphosphate contains considerable sulphur in the form of gypsum, while the metaphosphate contains very little, if any. Since plants need considerable sulphur for proper growth, the continued use of metaphosphate on some soils may give poorer yields than superphosphate with its high sulphur content.

3. When used as a top-dressing, calcium metaphosphate gives quicker response on pastures than on established meadows. Perhaps this is because pasture plants, especially bluegrass and wild white clover are able to feed nearer the surface than the deeper-rooted hay-type plants such as timothy and red clover.

4. Since calcium metaphosphate is a highly concentrated material, it is often difficult to apply small quantities. On dairy farms there are some advantages in using it with farmyard manure.

   a. It makes a convenient way to apply small amounts of the concentrated phosphatic material.

   b. It makes the manure a better balanced fertilizer.

   c. The manure protects the phosphate from excessive fixation in soils and thus increases its availability.

   d. Since calcium metaphosphate is slowly soluble, it has no appreciable effect in saving nitrogen in manure; while superphosphate is quite effective in this respect, especially when applied in a clean gutter. However, when superphosphate is not available, the metaphosphate may be used in this way since it becomes well mixed with the manure.

5. Potassium metaphosphate is a good source of both potash and phosphate for hay and pasture plants. It seems to be almost equal to a mixture of calcium metaphosphate and potassium chloride on an equivalent phosphorus and potash basis. The potassium metaphosphate used in these studies seemed to be too finely ground for most efficient use. In this finely ground condition, it was not only difficult to apply since it readily blows away, but its fine condition favors such

intimate contact with the soil that fixation is increased and its availability reduced. Potassium metaphosphate is quite soluble and it penetrates soil (moves downward) more readily than the calcium phosphates. When it is finely ground, penetration is thus increased and on high phosphate fixing soils, this excessive soil contact often decreases its chemical availability for plants. In the podzol soil region, it seems advisable to either pellet the material or grind it less finely.

6. Calcium-potassium metaphosphate was slightly better than the potassium metaphosphate in three field experiments but it also was too finely ground for most efficient use.

Title: Comparative Longevity and Yield Tests with 10 Grasses and 5 Legumes.

Leaders: A. R. Midgley and D. E. Dunklee.

Trials are being conducted on two distinct soil types--Copake fine sandy loam and Addison clay loam. The former was seeded May 12, the latter June 4, 1943. The seedings were made on land previously plowed, limed and fertilized and a good seedbed prepared.

The grass species used were as follows: Brage orchard grass, ordinary orchard grass, S-26 orchard grass, creeping bromegrass, non-creeping (smooth) bromegrass, Milton timothy, ordinary timothy, meadow foxtail, tall oat grass, and tall meadow fescue. The five legumes used were: Ladino clover, red and alsike clovers, alfalfa, and birdsfoot trefoil. The legumes were seeded across the grass plots, so that each legume will be in combination with each of the grasses. Good stands were obtained with all seedings and they went into the winter in good condition after taking a light cutting in late August.

The value of magnesium and borax as fertilizers for these legumes and grasses is being tested on the Copake fine sandy loam. Borax already appears to benefit the legumes even in their first year. It is too early to predict further results.

Title: Cytogenetics and Breeding Investigations with Forage Legumes.

Leader: A. Gershoy.

I. Experiments with Trifolium medium.

Although this species has been found growing naturally in several isolated areas in the Northeast Region, its agronomic usefulness may be limited because of its poor seed set under unfavorable conditions. Experiments begun in 1942 have been designed to investigate the causes of this difficulty. Observations on isolated native stands and on isolated plantings of only six to 12 clones have indicated a seed set of less than three per cent. In the latter case the infrequency of bee visits appeared to be an important limiting factor. In another planting, however, consisting of 15 parental clones together with certain F_1 progenies derived by open-pollination, the seed set in many of the plants ranged from 50 to 65 per cent. All evidence suggests that the highest seed set is obtained when many different genotypes are associated.

Bumble bees have been observed to be the most frequent visitors to zigzag clover. This uncontrolled bee activity probably accounts for much of the variability in seed set.

To test for self-fertility, a few parental and F_1 clones were selected in the field. From several thousand florets in flower heads enclosed in a muslin bag and rubbed by hand daily, no seeds were obtained. Similarly from heads isolated on a few plants in the greenhouse and rubbed to insure selfing, less than one per cent seed set was secured.

A majority of the crosses made by hand in the greenhouse proved compatible.

Modifications have been developed for the method of staining pollen tubes in the style, and with this method it was shown that tube growth following selfing is poorer than that following open-pollination in the field.

Seed gathered from several clones and planted either in moistened quartz sand or in clay cups shortly after harvest and without scarification germinated less than one per cent.

The same results were obtained with similar seed subjected to previous freezing and thawing. On the other hand, scarified seed gave almost perfect germination. Old seed germinated well without pretreatment.

In the field chalcid fly parasitization seriously reduces the yield of good seed.

Preliminary cytological observations indicate a 2n chromosome number of about 78 or 80. Meiotic irregularities and poor pollen have been noted. The presence of small abortive embryos suggests zygotic sterilities.

Selections for breeding purposes have been made from rosette, lax, erect, early, late, and freely blooming types.

A further test for incompatibility is being made with diallel crosses.

II. Strain trials with Trifolium pratense:

Several local Vermont strains obtained on the open market were grown in comparison with selected strains supplied by the U. S. Department of Agriculture and by the Ottawa Experimental Farms. A pure seeding at a heavy rate was used for each of the plots, 6 feet by 40 feet, all sown in the spring of 1942 on Melrose fine sand loam. No yields were taken during the first summer, but records were made of establishment, vigor of growth, period and extent of flowering, and susceptibility to rust, mildew and anthracnose. Manhardy late flowering and especially the Montgomery late strains showed poor germination under the dry conditions in 1942, but only minor differences were noted for the local, U. S. Department of Agriculture, and Canadian strains, all of which germinated moderately well.

All plots were cut twice in 1943. The U. S. Department of Agriculture and Canadian strains yielded highest, but some of the local strains, supposedly mixtures of the Midland strain, yielded nearly as well. Slight

differences in incidence of rust and mildew were not significant. Well defined differences were obtained, however, in degree of lodging. Late flowering appeared to be correlated with high yield.

It is planned to obtain data on both yield and survival during the third season of growth in 1944.

III. Preliminary strain trials of several legume species grown in association with grass:

In the spring of 1943 plots were established of T. pratense (both U. S. Department of Agriculture and Canadian strains), T. repens (including Ladino clover), T. fragarium, Melilotus spp., Medicago spp., and Lotus spp. The legume seed was inoculated, mixed with various grasses, and sown on plots, 10 feet by 20 feet, on moderately heavy Addison clay-loam. Observations were made on germination, first-season growth, recovery after cutting, and relation of type of cutting to relative legume-grass growth. Marked differences were obtained with the different grasses grown with Ladino clover and especially with Lotus. In the latter case, the crowding effect of redtop was conspicuous, whereas the Lotus-timothy combinations gave the best total number and vigor for this legume. It is expected to take yields on these plots in 1944.

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Title: Pasture Fertilization Studies.

Leaders: F. W. Schaller and G. G. Pohlman.

Yield data and botanical estimates were obtained from the small plots at Morgantown which have been under study since 1930. There are no new developments to report from the use of lime and fertilizer.

In September 1943 a detailed study was made of the weeds on these plots to determine the effect of clipping and applications of lime and fertilizer on the kind and quality of weeds. The area occupied by weeds varied from approximately 25 per cent on the

untreated plots to 18 per cent on those receiving complete fertilizer and lime. A great number of common weeds were identified on all these plots but only the five most common ones will be discussed here. On the untreated pasture Antennaria and cinquefoil were the two most prevalent weeds, followed in order by yarrow, heal-all, and buckhorn plantain. On the plots which received lime alone or superphosphate alone the order of occurrence was about the same except that yarrow was most abundant.

On the plots which received lime and superphosphate or lime, superphosphate, and potash, the five most common weeds occurred in the following order: Yarrow, buckhorn, heal-all, Antennaria and cinquefoil. The use of nitrogen fertilizer, in addition to lime, superphosphate, and potash almost completely eliminated the Antennaria and cinquefoil. The order of weed occurrence on these plots were yarrow, buckhorn, heal-all, violet, and ground ivy.

A survey of the weeds was also made in the untreated pasture surrounding the clipped plots. This area was moderately grazed but was never mowed. On this area the most prevalent weeds were tall-growing types and the five which occurred most abundantly were yarrow, Aster erocoides, goldenrod, ironweed, and heal-all. By comparing the list of weeds on this grazed unmowed area with that from the clipped plots it was observed that clipping had almost entirely eliminated many of the tall-growing and woody-type weeds such as ironweed, ragweed, muletail, milkweed, agrimony, dewberry, blackberry, greenbriar, rose, Virginia creeper, sumac, crapabble, and hawthorne.

Four years' results are now available from the study of rate and frequency of superphosphate application. Marked differences, especially in the magnitude of response, are evident among the three different soil types used in the experiment. At Wardensville on Westmoreland silt loam, treatment has effected very little change in desirable species and as a result there has been very little response to lime and superphosphate. The site has proven to be an unusually dry one and is probably the chief cause of the low response. The response on Monongahela silt loam at Milton and on Frederick silt loam at Lewisburg has been much greater and the four years' results can be summarized as follows:

1. There was a marked response from each increment of superphosphate up to 800 pounds per acre. Twelve hundred pounds per acre gave a small additional increase.

2. The superphosphate was about equally effective when applied in one application or in split applications at two year intervals.

3. A somewhat greater response occurred when the lime was applied in the fall and followed by superphosphate in the spring as compared to applying both the lime and superphosphate in the fall.

4. The response from potash in addition to lime and superphosphate was very small.

Title: Pasture Management.

Leaders: F. P. Schaller and G. G. Pohlman.

Since the white clover has almost completely disappeared on the plots used for the Kentucky bluegrass-white clover height of cutting experiment, a number of the plots were retreated in the fall of 1943. A study will be made of the effect of superphosphate, potash, and nitrogen on the re-establishment of white clover in these plots. Three levels of potash will be used. These will be applied every two years to plots having three levels of superphosphate. Two nitrogen treatments will be used; in the first, nitrogen will be applied in the spring of each year and, in the second, the nitrogen will be applied in the spring of years when no clover is evident. The latter treatment is an attempt to supply nitrogen to grasses in no clover years.

Title: Pasture Revegetation Trials.

Leaders: F. P. Schaller, R. M. Smith, and G. G. Pohlman.

The trials started at Morgantown in 1941 (1942 Annual Report, Page 107) were continued. In 1943 the surface treated area produced 2037 pounds of dry forage. The area which was fertilized, disked, and seeded produced 31 per cent more forage, and the area which was plowed, fertilized, and seeded produced 39 per cent more forage. The stand of legumes on these plots consisted mainly of white clover with some red and alsike clover. The percentage stand of these legumes averaged 9, 12, and 25 per cent, respectively, on the surface treated, the disked and the plowed plots. On these same plots, the stands of desirable grasses consisting mainly of redtop, orchard grass, and Kentucky bluegrass averaged 10, 20, and 46 per cent, respectively.

In the spring of 1943 ten additional trials representing six soil types were established in different parts of the state. These trials, although somewhat different in design, were in general similar to those established at Morgantown. As would be expected, the resulting stands were quite variable at different locations. In general, however, better results were obtained on the surface-tilled plots, that is, those worked up with a disk or spring-toothed

harrow, than on the plowed plots. The stands of grasses and legumes, especially legumes, were higher on the surface-tilled plots. These stands tended to vary with the degree of tillage. The best stands were obtained where the tillage was thorough enough to tear out and kill most of the existing vegetation. No appreciable erosion was observed on any of the areas where surface tillage was used. Slopes up to 25 per cent were represented. Plowed strips on the other hand suffered some erosion.

Successful seedings were obtained with sweet clover, alsike clover, red clover, white Dutch clover, alfalfa, and Korean lespedeza. Success with Ladino clover and birdsfoot trefoil was very limited. Among the grasses, redtop, orchard grass, and ryegrass show the most promise, in addition to Kentucky bluegrass, which comes slowly but is believed to be hastened by seeding. Timothy seems of little value. Bromegrass may prove suitable on further trial.

Two attempts at fall seeding on plowed and disked areas failed because of dry weather.

LIST OF PASTURE PUBLICATIONS BY STATES - 1943

CONNECTICUT

Brown, B. A., and Munsell, R. I. Pasture investigations (Tenth Report): The effects of fertilizers on grazed, permanent pastures. Connecticut (Storrs) Agr. Expt. Sta. Bul. 245. 1943.

Brown, B. A., and Munsell, R. I. The boron content of certain forage and vegetable crops. Jour. Amer. Soc. Agron. 35:401-408. 1943.

Brown, B. A., and Munsell, R. I. Fractional liming for alfalfa. Soil Sci. Soc. of Amer. Proc. 7:279-282. 1942.

Brown, B. A., and Munsell, R. I. Grasses fertilized with nitrogen compared with legumes for hay and pasture. Jour. Amer. Soc. Agron. 35:811-816. 1943.

MAINE

Dove, W. Franklin. Palatability of forages. Maine Agr. Expt. Sta. Bul. 420:497-499. 1943.

Fink, D. S. Grassland experiments. Maine Agr. Expt. Sta. Bul. 415. 1943.

Fink, Delmar S., and Chucka, Joseph A. Grassland fertilization. Maine Agr. Expt. Sta. Bul. 420:495-497. 1943.

NEW HAMPSHIRE

Phillips, T. G., Smith, T. O., and Harper, R. H. The composition of timothy. N.H. Agr. Expt. Sta. Tech. Bul. 81. 1943.

PENNSYLVANIA

Noll, C. F., Bechdel, S. I., Williams, P. S., Skaggs, S. R., and Hein, M. A. Pasture fertilization. (In press.)

RHODE ISLAND

Banfield, William G., and Stuckey, Irene H. The extent of intercrossing among species of Agrostis. (In press.)

VERMONT

Dunklee, D. E., and Midgley, A. R. Need and use of boron for alfalfa. Vt. Agr. Expt. Sta. Bul. 501. 1943.

Midgley, A. R., and Dunklee, D. E. Spreading lime with manure. Vt. Agr. Expt. Sta. Pamph. 6. 1943.

Midgley, A. R., Mueller, W. O., and Dunklee, D. E. Borax and boric acid for control of flies in manure. Jour. Amer. Soc. Agron. 35:779-785. 1943.

WEST VIRGINIA

Pohlman, G. G., and Cornell, F. D. Pasture improvement in Upshur County. W. Va. Expt. Sta. Bul. 308. 1943.

SUBJECT INDEX TO STATE REPORTS